TREASURE

D8.1: Exploitation plan (1st version)

31/05/2023 (M24)

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Technical References

Project Acronym	TREASURE
Project Title	leading the TRansion of the European Automotive SUpply chain towards a circulaR future
Project Coordinator	POLITECNICO DI MILANO (POLIMI)
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V1.1	02/05/2023	ILSSA
V1.2	06/05/2023	POLIMI
V1.3	15/05/2023	SUPSI
V1.4	19/05/2023	MARAS
V1.5	23/05/2023	UNIVAQ
V1.6	24/05/2023	TNO
V1.7	31/05/2023	EDGE, UNI
V1.8	01/06/2023	WALTER, SUPSI, TXT
VF	05/06/2023	UNIVAQ

[1] PU= Public
PP= Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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DISCLAIMER OF WARRANTIES

EXECUTIVE SUMMARY

The main aim of the TREASURE project is to develop new business models and industrial strategies for new supply chains in the automotive sector to enable value-added technologies and services. Through a set of success stories from the application of circular economy principles in the automotive sectors by involving all the stakeholders, TREASURE wants to demonstrate the real benefits of its adoption in practice. In addition, Exploitable Results (ERs) will be integrated within the selected processes to adopt the circular economy in the automotive sector for the recovery of precious, critical, and base metals.
Deliverable 8.1 focuses on defining the exploitation plan structure using, as a baseline, the draft exploitation plan presented in this proposal. To this aim, tangible and intangible results will be assessed in terms of:

a. an early definition of the TREASURE exploitation strategy;
b. identification of the TREASURE exploitable results and partners (or clusters of them) responsible for them;
c. definition of the targeted market;
d. preparation of individual exploitation plans defining roles and responsibilities, IPR, and ownership issues.

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1. Introduction

This document describes the initial Exploitation Plan customized for the TREASURE project, funded by the European Union's (EU) Horizon 2020 programme under the Grant Agreement (GA) No. 101003587.

This is the first version of the Exploitation Plan. This document will be updated during the project. The final official version of this document will be available to the consortium by M36.

According to the Grant Agreement (Article 3), all involved partners are obligated to take necessary measures to ensure proper exploitation of the projects' results for up four years after the end of the project. TREASURE Exploitation Plan aims to cover the most important topics concerning the identification of the project results as well as the methods of exploitations (including all relevant information). The current draft version of the Exploitation Plan includes the definition of the early exploitation strategy, a list of the exploitable results that have been identified from the project activities, the individual exploitation plans, the definition of targeted market, and the exploitation roadmap. In addition, potential connections between the exploitable results, with the aim of evaluating also joint exploitations, have been identified.

2. Innovation objective of Treasure and their management

2.1 Innovation objectives

The main objective of the TREASURE project is to guarantee sustainable use of raw materials by reducing their supply risks, to adopt the circular economy paradigm, to offer better vehicle-related economic, environmental, and social performances to all the end users, and to create new supply chains around End-of-Life-Vehicles (ELVs) by focusing on circular exploitation of raw materials embedded into cars. TREASURE will concretely support companies in the automotive sector by demonstrating in practice the benefits obtainable from exploiting this approach through adopting Industry 4.0 technologies in ELV management processes. TREASURE wants to demonstrate in practice the real benefits coming from its adoption. To achieve the goals of the project, 21 Exploitable Results (ERs) have been identified (see Table 1).

Table 1. List of TREASURE Exploitable Results

No.	ER title	Lead partner	Link with other partners (internal and *external*)	Confidentiality
1	SMD identifier V1	POLIMI	none	no
2	Learning GUI	POLIMI	none	no
3	Eco-design & IMSE technology development	TNO	WALTER *TACTOTEK, NANOGATE, FORVIA, IEE*	yes
4	Sustainability & circularity Assessment methodology	SUPSI	none	yes
5	Sustainability & circularity Advisory methodology	SUPSI	TXT	yes
6	Selling process engineering + licenses of recycling processes	UNIVAQ	POLLINI, ILSSA, POLIMI *SWE, BFC*	yes
7	Selling turn-key pilot and industrial plant for the recyclers	UNIVAQ	POLLINI, ILSSA *SWE, BFC*	yes

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8	Recycling of LCDs	UNIVAQ	EUROLCDs, POLLINI, ILSSA, *BFC*	no
9	Recycling of silver from IME	UNIVAQ	TNO, WALTER	yes
10	Recyclability analysis and recycling rate calculations, design for recycling feedback/advice	MARAS	none	yes
11	Reiterated research tool on public perception of the procedures and processes related to recycling, ELVs and CE	EDGE	SUPSI, TXT, UNIZAR	no
12	Sustainable IME products	WALTER	TNO	yes
13	TREASURE Platform	TXT	SEAT, UNIZAR, MARAS, SUPSI	yes
14	Advice on recyclability of vehicle components and their disassembly methodology	ILSSA	UNIZAR, SEAT	no
15	Training and consultancy in circular economy	ILSSA	UNIZAR, SEAT	no
16	Knowledge of vehicle components and their composition to value and increase recyclability to improve circular economy	ILSSA	UNIZAR, SEAT	no
17	Methodology development for recovery of components from vehicles	ILSSA	UNIZAR, SEAT	no
18	Reduction of the use of rare metals recovering components of vehicles research in simpler materials	ILSSA	UNIZAR, SEAT	no
19	Improvements in eco-design of car parts to ease disassembly and improve recyclability	ILSSA	UNIZAR, SEAT	no
20	Strategic Standardization Roadmap	UNI	All interested partners can contribute to the realization of the roadmap. They may be involved depending on their technical expertise	no
21	CEN Workshop Agreement	UNI	All interested partners can contribute to the realization of the roadmap/CWA. They may be involved depending on their technical expertise	no

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2.2 Exploitable management

The management of the exploitation and the detailed elaboration of the exploitation strategy will be handled by UNIVAQ. As stated in the GA, UNIVAQ will be responsible for preparing, monitoring, updating the project's exploitable results, and managing IP protection and ownership rights/implementation during the project. In addition, POLIMI will develop the Business Models according to the Canvas Models.

Figure 1 shows the project's exploitation roadmap, including the achieved results at M24 and the next activities.

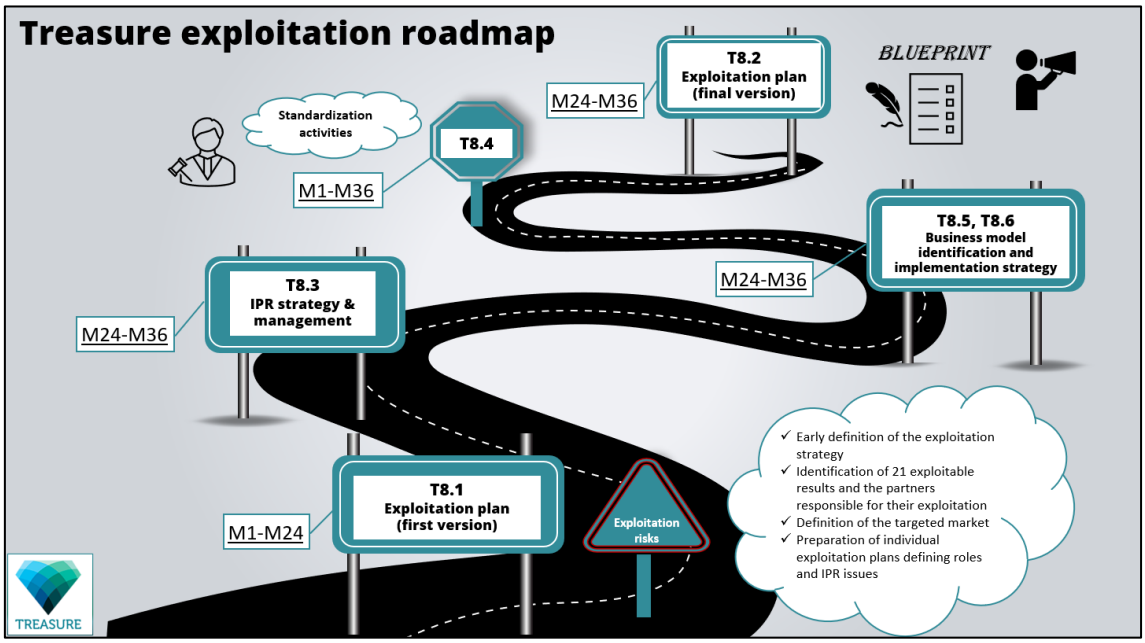

Figure 1. TREASURE exploitation roadmap

Achieved results, as described in detail in this deliverable, concern the early definition of the exploitation strategy, the identification of 21 ERs from different WPs and the partners or cluster of them responsible for their exploitation, the definition of the targeted market, and the preparation of individual exploitation plans defining roles, responsibilities, background - foreground IPR and exploitation risks with the corresponding mitigation actions. In addition, potential connections between the ERs have been identified, which will allow the evaluation of possible joint exploitations.

The next activities, as shown in the roadmap, are related to the appropriate use of IP rights, which is fundamental and strategic in the knowledge economy. IP analysis will be conducted to identify documents and communicate the existence of relevant background intellectual property that may affect project intellectual property rights, to expedite the disclosure and evaluation of project intellectual property, background IP, and related background research data, and to facilitate the effective dissemination of project intellectual property. In short, background IP introduced by a partner to TREASURE remains the property of the partner. Still, it is made available to other partners on a royalty-free basis for research-specific purposes if necessary to carry out the work agreed to in the project. Foreground IP created in the project belongs to the inventor, and in the case of joint inventions, IP rights will be shared equitably among the inventors. The background IP, based on the knowledge gained from previous research activities and participation in founded programs brought into the project by partners

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of the consortium, has been presented in the Consortium Agreement, signed by all the Parties. Then, a second stage of the IPR screening considers the external IP, what IPs are already on the market that needs to be taken into consideration, whether there are any hindrances for TREASURE to proceed to a market introduction, etc.
IP analysis is a very critical process, i.e., to reduce redundant searches, accelerate time to commercialization, and protect TREASURE project partners from defensive litigation. In the following external IP analysis, the key steps of the process were to research, review, and refine the subject matter and identify the most relevant based on the purpose of the study and the projected results projected of the analysis. The intellectual property agreement ensures the maximization of results from development to the go-to-market model. Patent mapping studies will be specified to propose IPR protection schemes. Using the exploitation plan, IPR studies will be performed to ensure that partners can use the results to either strengthen their market position or achieve their customer targets.
One of the main objectives of managing IPR is to control knowledge transfer and intellectual property rights from the beginning of the project. The partners recognize their expected results' scientific and commercial potential at TREASURE. Therefore, rapid protection of intellectual property rights will be a priority in the project to enable rapid industrial adoption and upscaling and rapid dissemination and exploitation of the results. IP protection decisions will be made by the partners who own it based on their agreements, strategies, and interests. The IP-generated and protected summary is presented during specific meetings at least every four months for discussion and feedback. When necessary, the IP manager advises the Parties concerned on the ownership of the intellectual property generated by the project, using the simple rules set out in the consortium agreement, and proposes protection strategies appropriate to the nature of the deliverable.

POLIMI will manage the business model identification by evaluating new-business models related to the TREASURE platform. More in detail, this activity will focus on product selling and usage selling. TREASURE outcomes will be assessed and adapted to the considered supply chains; the aim is to generate a win-win situation that benefits all stakeholders. TREASURE wants to develop an innovative CE scenario assessment tool for the automotive sector, trying to evaluate the business potential of TREASURE. Canvas business model can be considered a first step towards fully exploiting TREASURE results. Revenue streams, cost structure, feasibility check, and TREASURE platform’s investment analyses will be evaluated and implemented.

The following exploitation models will be considered, within M30, as presented in the proposal:

a. the consortium participants will set up a jointly owned spin-off company to market the platform technology;
b. one or more consortium participants will set up a revenue-shared business between themselves to offer the findings of the individual application/use case;
c. the consortium will sell/distribute exploitation rights to third parties on the basis of royalties, or
any other ideas.

Exploitation routes can be commercial or not, but anyway, technical aspects are necessary, but for exploitation, one of the crucial points is ensuring that TREASURE outcomes are focused on the users' needs. It must be avoided that the results are only interesting for the partners at the research level of research and from a technical point of view but are weak for the end users. In this case, a market analysis is essential to evaluate alternative user groups or new geographical

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areas to which the innovations can be transferred or to modify the technical solution so that it's available to other market segments after the project is completed. Industrial partners will best guide the consortium to ensure the identification of marketable results. The solution that TREASURE intends to develop and bring to market is derived from the needs of customers, mainly in the automotive sector, but also from the needs of tier suppliers. Customers can improve their benefits by adopting the circular economy, disassembling critical vehicle parts, and recovering materials that would otherwise have to be disposed of and would no longer reach the market. End users, in turn, are looking to create new revenue streams while reducing their environmental footprint and saving on operating costs. The TREASURE consortium, therefore, offers a sustainable solution, using innovative technologies fully described in the ERs' individual plan to the end users, which can facilitate the industrial transition towards a circular economy. With the aim of achieving the above-described objectives, a blueprint will be prepared. This document offers the innovators a step-by-step guide to taking innovations to market and provides tools to evaluate, monitor, and report progress. The blueprint will include all the questions that partners must consider on their market path. UNIVAQ and MARAS will cooperate for the drafting with different partners based on the specific use cases. ELV management industry will be implemented by SEAT, ILSSA, and POLLINI. WALTER will focus on the flexible printed electronics industry and EUROLOCDs in the car electronics industry. The blueprint document will include drafting plans for the medium-to-long perspective (2-5 years) and the identification of the TREASURE's exploitation market, such as customers for the targeted innovations based on existing networks of suppliers, material buyers, and other stakeholders.

3. Exploitation plan structure

This chapter will set out the general structure of the TREASURE Exploitation Plan. The segments listed below will be elaborated and discussed into detail during the project. The information required for the completion of the Exploitation Plan will be collected via internal consortium meeting, and via advisory board meeting.

3.1 Exploitable innovations and ambitions

This section provides a description of the innovation generated by TREASURE, state of the art, advantages and disadvantages compared to similar existing products, technologies, and services.

3.1.1 Technical description

This section includes a technical description of the innovation or services.

3.1.2 Innovation properties and benefits

This section includes a brief description of the value proposition (including added value).

3.1.3 Limitations

This section includes the potential limitation of the innovation (if any).

3.2 Exploitation strategy

An exploitation strategy to investigate the paths how the innovations of TREASURE can be exploited and addressed to the market, by identifying the end-users. This section is also developed based on feedback provided by members of the advisory board during the online meeting taken place on 31 March 2023.

3.2.1 Exploitation routes and guidelines

The exploitation routes and the timeline of the execution during the project. This includes the necessary steps during the lifetime of the project, as well as after the end of the project.

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3.3 IPR strategy

Issues related to the protection of intellectual property (before, during and after the project), are discussed in this section.

The European IP Helpdesk[2] is a useful tool to support the ER leaders in manage, disseminate, and valorize their IP. Informative materials, Helpline services for direct IP support and online trainings must be considered to provide capacity building along the full scale of IP practices and guarantee a successful exploitation.

A description and a brief analysis of the filed patents will be provided in this section.

3.3.1 Background IP access and ownership

Description of the background IP, developed by partners prior to the start of the TREASURE project, will be provided in this section. This section also includes an overview of limitation and conditions of utilizing the background IP for future exploitation.

3.3.2 Foreground IP

A description of the foreground IP and the method of protection will be provided in this section. It also includes a detailed IP strategy (that will be reported in the final version – M36) and a description/brief analysis of the field patents.

3.4 Exploitation risk management

Include in this section a description of the exploitation risks, as it might impact the successful exploitation of the project results. The risks will be identified based on internal and external sources (via Risk Matrix).

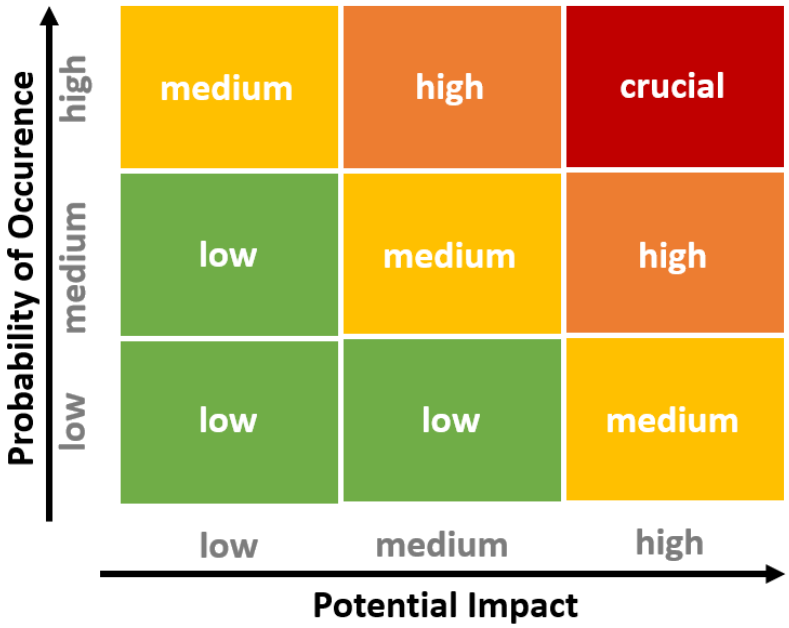

Figure 2. Risk matrix – probability of occurrence vs potential impact

The following types of risk should be included in the choice of risks: technological risks (closely related to the exploitable result), market risks, IPR/legal risks, management risks, environmental risks, and safety risks.

[2] https://intellectual-property-helpdesk.ec.europa.eu/index_en

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For some of the identified risks, mitigation actions will be proposed to the reduce the risk grade.

4. Exploitation plan: ER#1

Table 2: TREASURE ER#1 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
1	SMD identifier V1	POLIMI	none	Research and didactic purposes

4.1 Exploitable innovations and ambitions

In the last years, POLIMI developed a PCB disassembly process to support downstream recycling processes. To this end, a first solution was presented in the context of the H2020 project FENIX[3] and the efforts to implement a flexible and profitable solution are continuing. Under these terms, several technologies have been considered to optimise the process and assist the operator. Among them, one of the most relevant is the development of a software capable of extracting useful information from PCB images. In addition, trying to gather the greater potential of vision software, a dedicated section for image acquisition has been set up within the POLIMI's Industry 4.0 Lab. This section presents a controlled environment in terms of light and exposure allowing an optimal image acquisition.

4.1.1 Technical description

An algorithm was created to reconstruct and communicate the presence of Surface Mounting Devices (SMD) components to a cobot, and an optimal environment was created for the acquisition of PCB images. The algorithm was developed in Python with the OpenCV library, and it consists of a pipeline of several algorithms extracting the contours of all components on the board. The image is, then, binarized through various CV algorithms, leaving only the contours of components on the board (highlighted, so easing the cobot to reach them).

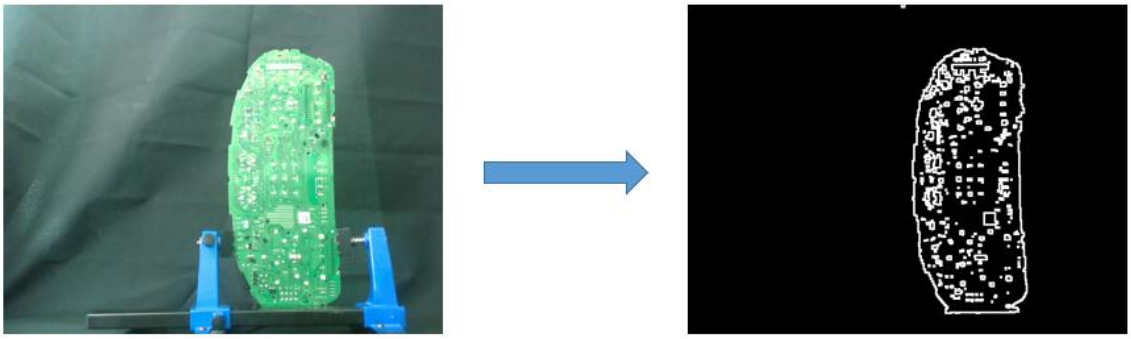

Figure 3. Pre-processed PCB image and post-processed PCB image

4.1.2 Innovation properties and benefits

The algorithm, although not 100% accurate, is very simple and it allows a rapid execution to extract features from the image if the acquisition is performed in a controlled context. Although

[3] https://www.fenix-project.eu

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algorithms capable of identifying specific components present on boards exist in the literature, the presence of algorithms capable of extending cognitive capabilities to all components is scarce. This algorithm makes it possible to identify the presence of any component on the board by isolating components from the substrate, extending the applicability of this type of solution not only to the automotive electronics sector, but also to any electronic board.

4.1.3 Limitations

Although the system is relatively flexible, the critical points arise from the fact that it is necessary to manually calibrate certain parameters of the code to ensure the optimal operation with all PCBs. Furthermore, the algorithm does not present an optimal solution to the problem, but it was a first step in that direction paving the way for future developments.

4.2 Exploitation strategy

The full exploitation strategy is not yet defined. However, it may include use for further research as well as use for future standardization activities.

4.3 IPR strategy

The IPR strategy is not yet defined.

4.4 Exploitation risk management

Currently no exploitation risk is foreseen.

5. Exploitation plan: ER#2

Table 3. TREASURE ER#2 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
2	Learning GUI	POLIMI	none	Research and didactic purposes

5.1 Exploitable innovations and ambitions

In the context of the development of a PCB disassembly process, POLIMI focused on the potential of human-robot interaction. The advantages of such interaction emerge clearly in literature, although there are not so many real-life applications of cobots supporting operators. An initial approach was developed in the context of the H2020 project FENIX, where the interaction between a cobot and an operator took place via keyboard control. In the context of TREASURE, an attempt was made to further increase this interaction, by allowing the operator to control and teach some basic operations to the cobot via a Graphical User Interface (GUI).

5.1.1 Technical description

To support the operator during the disassembly of PCBs, a GUI was developed to speed up and simplify the interaction between the operator and the cobot. The application was developed in the ROS environment and the code was implemented in Python. The GUI allows the operator to teach new operations to the cobot, check them through a simulation tool, save them and then execute them on call. A suitable simulation environment was developed in Rviz, allowing the operator to check the learning procedures before executing them in a real environment.

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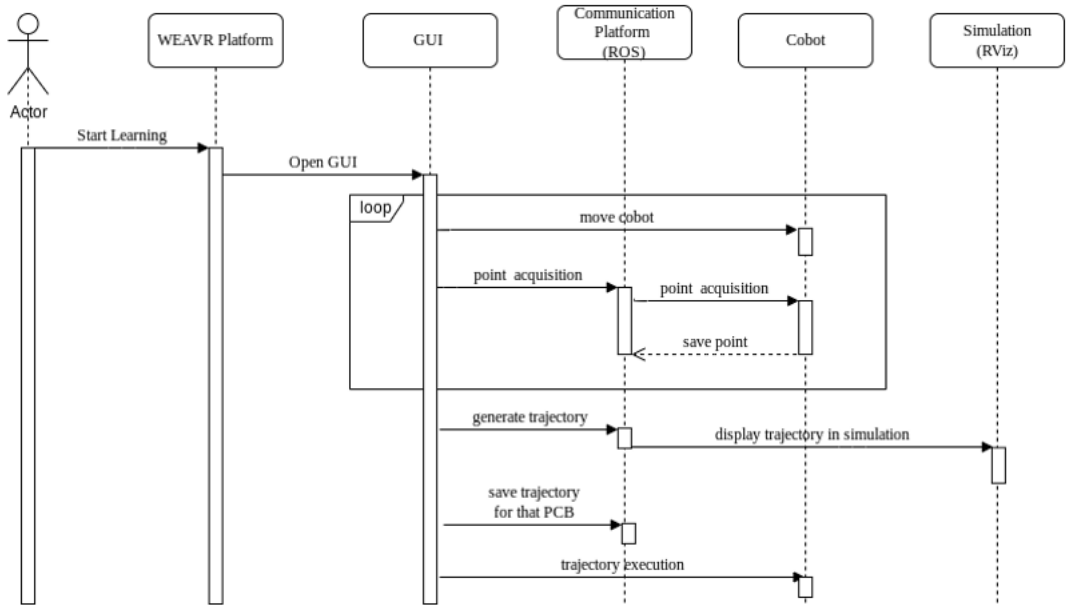

Figure 4. UML schematics of the GUI's functionalities

5.1.2 Innovation properties and benefits

The implementation of the GUI simplifies the operator's interaction with the cobot, by favoring the human-robot interaction. The GUI is designed to make learning operations quick and executable, even for those people not particularly familiar with cobots.

5.1.3 Limitations

Interchangeability is guaranteed only if the adopted cobot is correctly configured with the necessary drivers in order to work in an ROS environment.

5.2 Exploitation strategy

The full exploitation strategy is not yet defined. However, it may include use for further research as well as use for future standardisation activities.

5.3 IPR strategy

The IPR strategy is not yet defined.

5.4 Exploitation risk management

Currently no exploitation risk is foreseen.

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6. Exploitation plan: ER#3

Table 4. TREASURE ER#3 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
3	Eco-design & IMSE technology development	TNO	WALTER *TACTOTEK, NANOGATE, FORVIA, IEE*	Tier suppliers to automotive

6.1 Exploitable innovations and ambitions

6.1.1 Technical description

The IMSE eco-design facilitates end-of-life recycling. This will help IMSE suppliers to automotive comply with future sustainability legislation.

In the initial stages of recycling, the dismantling occurs at the interface of the dismantling layer and the injected polymer resin, thereby exposing the Ag circuitry and SMD components that would otherwise remain trapped within the plastic. This way, the printed silver and metals in the SMD components can be recuperated.

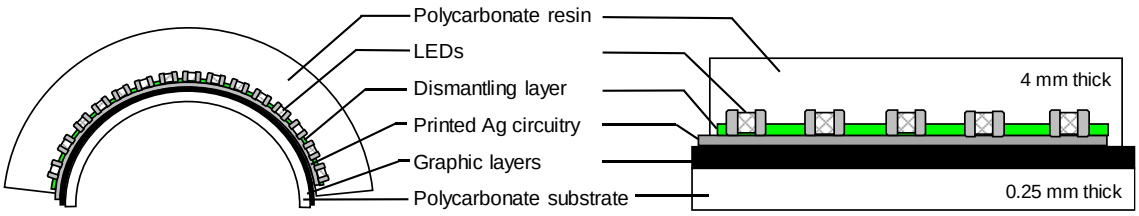

Figure 5. Device lay-out including a dismantling layer to facilitate EOL dismantling of IMSE parts

6.1.2 Innovation properties and benefits

Dismantling of IMSE has not been demonstrated prior to the TREASURE project and creates a credible route to recyclable IMSE products. Separating the elements from the device, namely Ag, SMDs and plastic, allows more dedicated recycling to take place with higher efficiencies. A high-quality recuperation of Ag and plastics reduces the environmental impact of the parts and enables compliance of the Tier suppliers to EU legislation regarding eco-design and circular economy.

6.1.3 Limitations

Materials with high reliability (e.g. in damp heat test) while retaining disassemblability. Degree of recovery of materials (Ag, PC).

Adoption of industry of eco-designs for IMSE.

6.2 Exploitation strategy

A general patent for recyclable printed electronics devices was filed prior to the TREASURE project and became available during the project. It is currently available for licensing (WO2022220688). In addition, TNO offers services including technology and prototype development up to the point of commercialization. Results from TREASURE will benefit other projects directly or indirectly if these also focus on higher sustainability in printed electronics.

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6.3 IPR strategy

The IPR strategy is linked to the exploitation strategy as exploitation proceeds via licensing, consultancy and tech/prototype development using obtained IP.

6.4 Exploitation risk management

Currently no exploitation risk is foreseen other than potential gaps in IP. Reliability testing and finding suitable materials is critical. Further risk mitigation is not necessary as sufficient materials are commercially available or are being designed for the purpose.

7. Exploitation plan: ER#4

Table 5. TREASURE ER#4 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
4	Sustainability & circularity Assessment methodology	SUPSI	None	Students, industrial professionals, consultancy companies

7.1 Exploitable innovations and ambitions

Over the course of the project, SUPSI developed an assessment methodology collecting sustainability and circularity impact assessment methods for the performance evaluation of TREASURE project's activities under the triple bottom line perspective, complemented with the Circular Economy perspective. For each sustainability and circularity area, a set of indicators, a selection of assessment methods, and an aggregation methodology are provided.

7.1.1 Technical description

The Sustainability and Circularity Assessment methodology developed within TREASURE, allows life cycle sustainability and circular assessment (LCS&CA) to be carried out in the different project use cases. The methodology is composed by:

- A selection of environmental, economic, social, and circular assessment methodologies from the analysis of state-of-the-art that fit the adoption context (e.g., project's use cases), such as environmental Life Cycle Assessment (LCA), Life Cycle Costing (LCC), Social Life Cycle Assessment (S-LCA), and Circular Footprint Formula (CFF) methods.
- A selection of existing assessment methodologies and standards to aggregate and integrate the three areas of sustainability and the circularity to provide a holistic interpretation of the assessment results, such as graphical representation of results.
- A selection of LCS&CA indicators proposed by methodologies and their respective calculation formulas according to criteria such as quantifiability and data availability.

7.1.2 Innovation properties and benefits

The methodology makes a step forward in the field of LCS&CA by identifying the most widely accepted and validated methodologies, indicators, and aggregation/integration methods. Starting from the project pilot cases, it is possible to extend the methodology adoption to off-project use cases in the future. This approach has been designed to ease the understanding in both the selection of appropriate aggregation methods and the choice not to aggregate results.

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ER#4 laid the foundation for the development of the advisory methodology and of SUPSI sustainability assessment tool. The LCS&CA-based tool will help to automate the previously described process, enabling data acquisition, automatic assessment calculation, aggregation, and results presentation.

7.1.3 Limitations

The literature, the standards, and the European policies are constantly evolving, so it is important to monitor ongoing developments in the LCS&CA field to keep the methodology here proposed updated, compliant with new regulations, and applicable across the industry.

7.2 Exploitation strategy

SUPSI increased its know-how in sustainability and circularity-related indicators and assessment, taking advantage of the possibility to access knowledge and expertise of several qualified partners and to strengthen and improve national and international contacts in research and industry.

The Sustainability and Circularity Assessment methodology has been developed leveraging gained expertise in the topic and extending the research activities towards the extensive, articulated, and constantly evolving field of LCS&CA aggregation and integration approaches. The resulting methodology constitutes the theoretical basis on which SUPSI sustainability assessment tool is developed. The tool, however, is not a direct result of TREASURE project.

7.2.1 Exploitation routes and guidelines

The full exploitation strategy is not yet defined. However, it may include the use of both methodology and tool to offer consultancy and services to companies, to integrate the results into courses held in SUPSI and the gained knowledge into new research projects and further research activities, and eventually to provide the tool through licensing. Therefore, the targeted end-users include students, industrialists, and eventually consulting companies.

7.3 IPR strategy

The IPR strategy is not yet defined.

7.4 Exploitation risk management

Currently no exploitation risk is foreseen.

8. Exploitation plan: ER#5

Table 6. TREASURE ER#5 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
5	Sustainability & circularity Advisory methodology	SUPSI	None	Students, industrial professionals, consultancy companies

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8.1 Exploitable innovations and ambitions

The Sustainability & Circularity Advisory methodology is a methodology able to support decision-making. The approach is specifically designed to facilitate decision-making processes related to disassembly, recycling, and eco-design of electronic components in the automotive industry.

The main objective is to promote the implementation of more sustainable and circular practices by maximizing the extraction of materials from end-of-life components and reintegrating them into the production cycle through recycling. In addition, this methodology serves as a guiding framework to assist in the design of electronic components with improved sustainability and circularity characteristics, also facilitating future disassembly and recycling processes.

The methodology underpins the Advisory tool, that is one of the functionalities of the TREASURE Platform, developed by TXT in WP4.

8.1.1 Technical description

The Sustainability & Circularity Advisory methodology focuses on the integration and enhancing of sustainability and circularity principles, able to support End-of-Life (EoL) product decision-making in disassembly and recycling phases of electronic components, and to support Beginning-of-Life (BoL) decision-making towards more sustainable and circular electronics design.

The methodology is based on the description of the decision-making process for each life-cycle phase included, structured in a series of decisions for which the methodology provides recommendations and best practices to be implemented. Specifically, for each identified decision-making moment, the methodology includes the following details:

- Decisions to be taken.
- Object of the decision: the focus of the decision, whether it is the entire product, a single component.
- Decision-maker profile: the suitable figure with the highest level of expertise related to the decision, responsible for making the decision.
- Input information: the required data or information to be processed to elaborate advice, e.g., the mass of raw materials present in the component under analysis.
- Supporting tools and technologies: the resources, such as databases, methodologies, and simulation tools, that can assist in the decision-making process.
- Potential Artificial Intelligence support: the possible utilization of Artificial Intelligence techniques to aid in decision-making.
- Environmental, social, economic, and circularity indicators: the indicators that should be calculated to facilitate decision-making.

In addition to decision-making support, a dedicated feedback mechanism is integrated. Decision-makers are expected to have the possibility to record critical issues encountered during the implementation of the processes under their responsibility.

8.1.2 Innovation properties and benefits

The innovative aspect of the Sustainability & circularity Advisory methodology relies on the creation and formalization of an advisory framework that considers the connections among the three stages (disassembly, recycling, design) of the value chain, framework that was still missing in the automotive field. The adoption of a feedbacks system across EoL and BoL actors supports closing the loop through information sharing and improving the sustainability and circularity

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performance along the value chain. The advisory methodology offers an integrated vision embracing technical, sustainability, and circularity aspects, trying to integrate, in the functional development and assessment, *i.* the economic evaluations in terms of cost and revenues, *ii.* the environmental evaluations in terms of processes' impacts, *iii.* the circularity evaluation in terms of the recyclability and thermodynamic rarity calculation, *iv.* the social evaluations in terms of risks for the stakeholders to be safeguarded according to the social goal and scope of the project.

8.1.3 Limitations

The Advisory tool developed in TREASURE project is based on the foundational Sustainability & Circularity Advisory methodology. Currently, main limitations are related to the not fully automated approach, resulting in a labour-intensive process. Furthermore, the methodology primarily emphasizes recycling as the predominant end-of-life strategy, without implementing other end-of-life strategies.

8.2 Exploitation strategy

SUPSI increased its know-how in decision-support methodologies, supported by sustainability and circularity-related indicators and supporting sustainability and circularity-oriented decision making.

The Sustainability and Circularity Advisory methodology has been developed leveraging gained expertise in the topic and extending the research activities including the application of sustainability and circularity decision-making in the automotive EEE value chain. The resulting methodology constitutes the theoretical basis on which two potential exploitation strategies has been defined: first, the methodology can be integrated in the SUPSI sustainability tool to enable further functionalities; secondly, the methodology is the theoretical basis of the Advisory tool in TREASURE Platform.

8.2.1 Exploitation routes and guidelines

The full exploitation strategy is not yet defined. However, two separated and not mutually exclusive routes are identifiable according to the exploitation type:

- In the individual exploitation, the methodology is integrated in the SUPSI sustainability tool, and the exploitation strategy may include the use of the methodology for the same aims (consultancy, teaching, research, licensing) of ER#4, targeting the same end-users (industries, students, researchers, consultancy companies).
- In the joint exploitation with TXT, the strategy is not yet defined and should be discussed in the upcoming months.

8.3 IPR strategy

The IPR strategy is not yet defined. Within TREASURE, the involved background mainly concerns SUPSI Sustainability Assessment Tool, owned by SUPSI.

8.4 Exploitation risk management

Currently no exploitation risk is foreseen.

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9. Exploitation plan: ER#6

Table 7. TREASURE ER#6 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
6	Selling process engineering + licenses of recycling processes	UNIVAQ	POLLINI, ILSSA, POLIMI *SWE, BFC*	Automotive dismantlers, Companies focused on waste recycling

9.1 Exploitable innovations and ambitions

UNIVAQ in the last 25 years has been engaged in the development of innovative hydrometallurgical operation to recover base, precious and critical metals from e-waste and other industrial waste. To complete the background UNIVAQ has been involved in other projects (with private company and in the ambit of EU calls: i.e., LIFE BITMAPS[4], FENIX[3], PEACOC[5], NEW-RE) also in the treatment of industrial wastewaters. Considering the developed knowledge UNIVAQ can carry out research activities in the field of Circular Economy giving a wider vision of this concept. In addition, the external partners SWE and BFC support UNIVAQ in basic engineering design.

UNIVAQ wants to enhance the hydrometallurgical processes for the treatment of printed circuit boards of different critical car components as for example combi-meter and infotainment unit. The processes allow to recover base and precious metals according to the UNIVAQ patents named Gold-REC 1 (International Publication number: WO2018/215967) and Gold-REC 2 (International Publication number: WO2019/229632).

9.1.1 Technical description

This technology consists in the treatment of PCBs from different car components through hydrometallurgical processes for the recovery of base and precious metals.
The PCBs, once disassembled from the car component, are subject to an additional disassembly level. This disassembly is intended to remove some components that inhibit the metal extraction yields during the hydrometallurgical processes, such as components containing organic compounds or with a high copper and aluminum content. In addition, with the aim to maximize the recovery yields are also removed some components as connectors, and different components that connect the PCBs with the LCDs like the flexible board and the small PCBs. These last components are removed for their high gold content (700 – 1000 g/t) and because they can be processed by Gold-REC 2 without any size reduction. The remaining part of PCB, from which several components have been removed but remain the integrated circuit chips and other valuable components, is subjected to a grinding process to obtain a dimensional reduction until a powder with a particle size less than 2 mm. The obtained powder, with a gold content in the range of 80 – 100 g/t, can be treated by Gold-REC 1 hydrometallurgical process to recover base and precious metals.
In Figure 6, the scheme of the two hydrometallurgical routes for the recovery of base and precious metals from PCBs is shown.

[4] https://www.lifebitmaps.eu
[5] https://www.peacoc-h2020.eu

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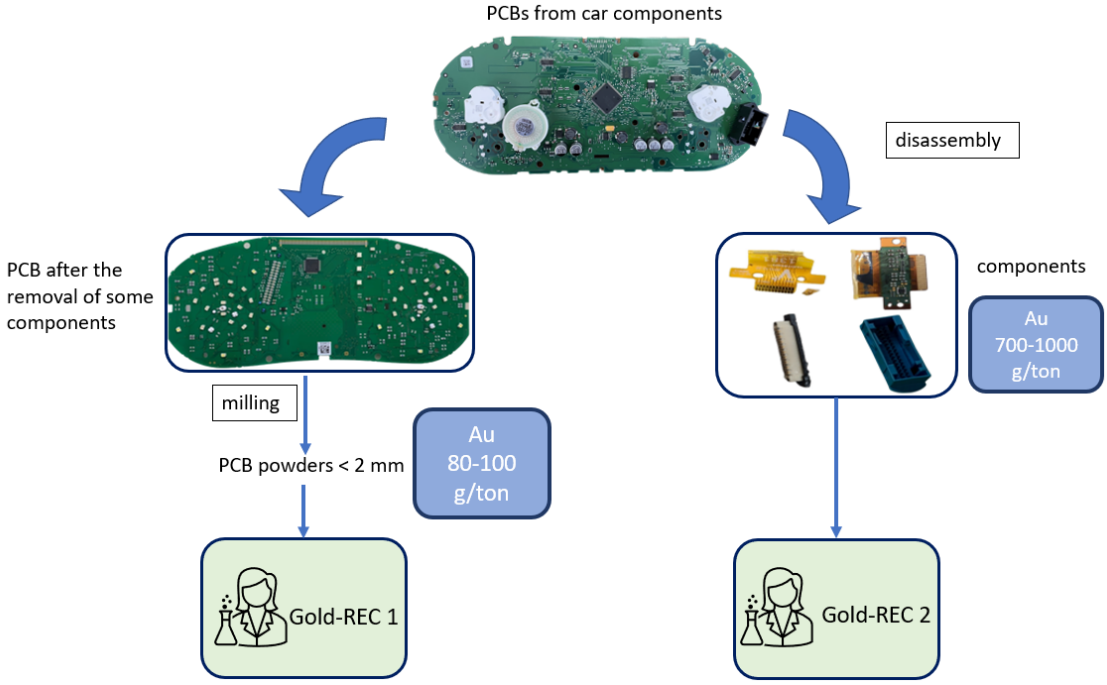

Figure 6. Simplified scheme of the two hydrometallurgical routes for PCBs treatment

9.1.2 Innovation properties and benefits

Although several papers are available in the scientific literature concerning the recovery of valuable metals from PCBs, only a few are addressed to the treatment of PCBs from critical car components. The added value of the following proposal is also related to the introduction of a disassembly operation. In fact, specific components from the PCBs are selected to be removed to maximize the precious metals recovery yields, and other components with a high gold content are removed to be processed independently without any size reduction. In addition, the patents of the hydrometallurgical processes allowed to minimize the production of wastewater according to counter-current leaching operations and the reuse of the solutions from which the metals are recovered for new cycles of PCBs treatment.

This innovation could be used in the following forms: process solutions with a Business Plan, research services and policy recommendations. More in detail, UNIVAQ can offer its expertise in the study of PCBs from critical car components by using the patented hydrometallurgical processes. Based on the available PCBs the hydrometallurgical processes will be optimized to reduce the chemical consumption and the production of wastewater. However, a lab-scale study phase is indispensable as the chemical composition of PCBs can affect the feasibility of the process. Subsequently, based on the obtained results, UNIVAQ will provide a business plan helping the companies as the automotive dismantler to understand the economic sustainability by providing the economic indexes as the return of investment, the payback time, and the gross operating profit.

9.1.3 Limitations

Currently, any potential limitation of the innovation has been considered.

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9.2 Exploitation strategy

UNIVAQ intends to exploit this technology in collaboration with the external company 'Smart Waste Engineering s.r.l.' (SWE) taking advantage of its expertise in the field of process design and sustainable and innovative environmental processes.
In addition, links with other internal partners as POLIMI, ILSSA, and POLLINI will be defined.

9.2.1 Exploitation routes and guidelines

The present technology is an innovative hydrometallurgical solution for the recovery of base and precious metals from PCBs from different critical car parts. The commercialization of this solution is closely related to the automotive sector, or, as in the case of the treatment of components rich in gold, you could also think of a combined plant that can treat with the same technology similar electronic waste.
The hydrometallurgical pilot plant, reconfigured under the TREASURE project, can also be used for the treatment of materials of interest to the end-users, to validate the process on a pilot scale.

9.3 IPR strategy

9.3.1 Background IP access and ownership

The proposed processes were tested within the TREASURE project on PCBs from combi-instrument of different car models. The hydrometallurgical processes named Gold-REC 1 (International Publication number: WO2018/215967) and Gold-REC 2 (International Publication number: WO2019/229632) are patented at European level.

9.3.2 Foreground IP

Further issues related to the IP will be discussed after assessing the actual contributions of the other partners with whom the present ER is linked.

9.4 Exploitation risk management

A list of identified risks is reported in Table 8 to assess their risk grade according to the risk matrix.

Table 8. ER #6 identification of risks

no.	Description of risk	Probability of occurrence	Potential impact	Risk Grade
Technological Risk Factors				
1	Technical problems associated with the scale-up of the process from laboratory scale	Medium	medium	medium
2	Decrease in the market price of gold	Low	high	medium
3	Increase in the market price of the hydrogen peroxide, used for the hydrometallurgical process	Medium	high	high
4	High costs related to the disassembly of PCBs from critical car parts	High	high	crucial
5	Loss of gold during the PCBs grinding operation	Medium	high	high

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6	Grinding operation not properly carried out	High	high	crucial
Market Risk Factors				
7	A more competitive process is developed	High	low	medium
IPR/ Legal Risk Factors				
8	New patents are issued recently in the same field	Low	medium	low
9	Weak marketing strategy	Medium	medium	medium
Financial/Management Risk Factors				
10	Weak exploitation plan	Low	high	medium
Environmental/ Safety/ Regulation Risk Factors				
11	Limitation in the use of the process chemicals	Low	medium	low
12	Restrictions in the authorization for plant building	Medium	medium	medium

For some of the identified risks the mitigation actions have been highlighted below:

- No. 1 – to carry out pilot scale tests, for example using the TREASURE hydrometallurgical pilot plant, to reduce the scale effect from the lab to an industrial plant.
- No. 3 – to identify an alternative oxidant agent to replace the hydrogen peroxide.
- No. 5 – to select a mill that has vacuum collectors for the recovery of fine powders.
- No. 6 – to use a properly mill to obtain a powder with a particle size below to 2 mm.
- No. 11 – to identify alternative chemicals.

10. Exploitation plan: ER#7

Table 9. TREASURE ER#7 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
7	Selling turn-key pilot and industrial plant for the recyclers	UNIVAQ	POLLINI, ILSSA *SWE, BFC*	Dismantlers, Recycling companies

10.1 Exploitable innovations and ambitions

UNIVAQ is interested in exploiting their results to develop process engineering and pilot-industrial plants construction (turn-key) to recover precious metals, base metals and REE through its spin-off (Smart Waste Engineering srl, SWE). Process engineering and industrial plant construction will be based on the IPR of UNIVAQ that will be discussed in the ambit of the Consortium in the next months.

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10.1.1 Technical description

Numerous systems for recovering precious and base metals from different types of waste are presented in the literature. In addition to these data, it is also possible to find a relatively large number of patents and licenses for pyrometallurgical, hydrometallurgical, and bio-hydrometallurgical extraction processes. Of these three categories of raw material recovery processes, the hydrometallurgy route seems the most promising. Pyrometallurgy allows very high recoveries of raw materials but with a significant environmental impact (high emissions of toxic substances). At the other extreme, we find bio-hydrometallurgy, which, although it is the greenest way, still needs to be consolidated at an industrial level today due to a whole series of problems relating to extraction yields and the greater difficulty of management compared to the other two ways. At the center of these two extremes, we find hydrometallurgy. Hydrometallurgical processes allow for high recovery yields with low environmental impacts. In light of these considerations, developing new hydrometallurgical processes is undoubtedly the most interesting way if one considers technical, economic, and environmental sustainability.

UNIVAQ fits into this panorama thanks to the experience gained over the last few decades in treating and valorizing industrial waste and effluents. Thanks to this experience and expertise in the hydrometallurgical and process engineering sectors, UNIVAQ could use the results obtained within the project to develop innovative processes to be presented on the market directly as pilots and turn-key industrial plants. Figure 6 outlines the exploitation and commercialization of the TREASURE results through ER#7. As can be seen from the graphs in Figure 7, hydrometallurgy is one of the most promising methods. UNIVAQ is a partner of SWE and in this start-up are present as other partners a process and control engineering company and an engineering and construction company. In this way it will be possible to have all the facilities to realize turnkey hydrometallurgical plants. With the proposed solution of ER#7 and the one that makes the object of this ER, there was possible to treat different electronic wastes and to achieve different base and precious metals products.

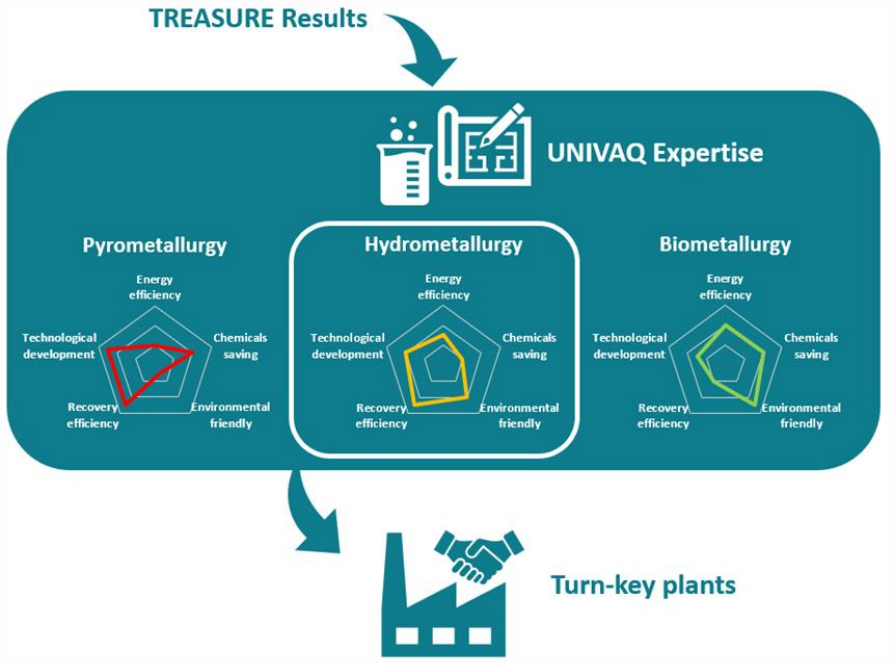

Figure 7. Scheme of valorization of TREASURE results for the ER#7.

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10.1.2 Innovation properties and benefits

The innovation aspects are linked to the IPR of UNIVAQ and of all the Consortium. The pilot plant tests results will be a key point to show the innovation potential of the findings to customers and to demonstrate the hydrometallurgical processes at TRL 6. Benefits of this activity are under study with the development of specific Business Plans and LCA.

10.1.3 Limitations

The existing pilot plant serves demonstration purposes. Its current capacity of treatment may be further improved.

10.2 Exploitation strategy

The already available pilot plant is a very useful showroom for potential customers.

10.2.1 Exploitation routes and guidelines

The exploitation of this ER consists in selling of services of Basic Engineering Design (BED) for processes and its licenses and the Engineering, Procurement and Construction of the plants.

10.3 IPR strategy

The IPR strategy is not yet defined.

10.4 Exploitation risk management

A list of identified risks is reported in Table 10 to assess their risk grade according to the risk matrix.

Table 10. ER#7 identification of risks

no.	Description of risk	Probability of occurrence	Potential impact	Risk Grade
Technological Risk Factors				
1	Technical problems associated with the scale-up of the processes	medium	medium	medium
2	Decrease in the market price of metals	low	high	medium
3	Increase in the market price of the chemicals used for the hydrometallurgical processes	medium	high	high
Market Risk Factors				
4	A more competitive process is developed	high	low	medium
5	Lack of investments	low	high	medium
IPR/ Legal Risk Factors				
6	New patents are issued recently in the same field	low	medium	low
7	Weak marketing strategy	medium	medium	medium
Financial/Management Risk Factors				
8	Weak exploitation plan	low	high	medium

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Environmental/ Safety/ Regulation Risk Factors				
9	Limitation in the use of the process chemicals	low	medium	low
10	Restrictions in the authorization for plant building	medium	medium	medium

For some of the identified risks the mitigation actions have been highlighted below:

- No. 1 – to carry out more pilot scale tests, for example using the TREASURE hydrometallurgical pilot plant, to reduce the scale effect from the lab to an industrial scale.
- No. 3 – to identify alternative chemicals.
- No. 10 – to identify alternative chemicals.

11. Exploitation plan: ER#8

Table 11. TREASURE ER#8 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
8	Recycling of LCDs	UNIVAQ	EUROLCDs, POLLINI, ILSSA, *BFC*	Dismantlers, Recycling companies

11.1 Exploitable innovations and ambitions

UNIVAQ is interested in exploiting the results achieved within the TREASURE project on the recycling of ITO glass by extending the added value to the better management of liquid crystals. In this sense UNIVAQ wants to enhance the hydrometallurgical process developed for the recovery of indium. Indium is one of the strategically important materials that have been defined as critical by several industrialized countries. In addition to the recovery of indium the process allows to also enhance other flows such as the glass, that currently from several recycling companies is disposed of, and liquid crystals. Moreover, by considering the LCDs in their totality there are other fractions like plastic (25% wt.), aluminium and galvanizing iron from the frame (45% wt.), and PCBs (8% wt.), where ITO glass is 7% wt. of the total LCDs. To increase the economic sustainability of the process also PCBs recycling by hydrometallurgical could be considered according to #ER6.
This aspect fits perfectly within the concept of the circular economy increasingly pursued globally.

11.1.1 Technical description

The technology consists of indium recycling from ITO glass of LCDs by the adoption of a hydrometallurgical process, developed by UNIVAQ within the project, that includes a multi-step indium dissolution and its subsequent recovery from the leach liquor solution by electrodeposition. In case of crystal liquids are over the ITO glass layers, two different preliminary washing treatments can be applied depending on whether you want to recover even the liquid crystals or if you just want to clean the ITO layers. Therefore, ITO glass consists of a glass substrate on whose surface there is a layer of ITO that can be either on one side or on both sides and then in a higher layer the liquid crystal.

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With the aim to minimize the operative costs of indium recycling and to also adopt an MLD approach, the leaching steps were optimized by a counter-current process that allowed to reduce the chemical consumption and the production of wastewater. The innovative adopted scheme was shown in Figure 8.

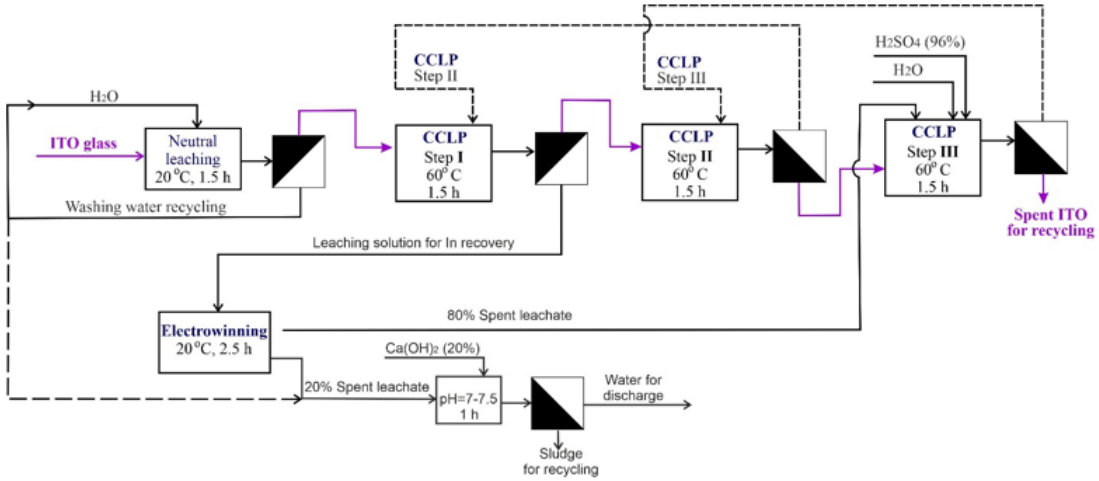

Figure 8. Flowsheet of ITO glass recycling focused on a counter-current leaching

The innovation is on the counter-current three stages leaching process, in which solid flow is counter current with respect to the leach liquor solutions. At the steady state process a low concentration of sulfuric acid (0.1 mol/L) was only added in one of the three steps. This way, a reduction in sulfuric acid consumption and wastewater production by one third is achieved compared to the initial scenario with three leaching steps with fresh solutions. The indium extraction yield is above 95%. In addition, after the recovery of indium by electrowinning the 80% v/v of the spent leachate is recycled to the leaching operations. A 20% purge always provides a suitable solution for indium leaching. A wastewater treatment with the aim of avoiding the disposal of wastewater to external companies with high processing costs was proposed.

11.1.2 Innovation properties and benefits

The developed hydrometallurgical process for the recycling of indium has an innovative content related to the low chemical consumption and low production of wastewater by exploiting the proposed counter-current leaching method. Although several papers are available in the scientific literature concerning the recovery of indium from LCDs, the added value of the following proposal is related to the develop of a process that can generate a profit. OPEX for a treatment of 1 ton of ITO glass is 127€, the higher item cost is related to the energy consumption for heating solutions during the leaching. Moreover, the full management of LCDs allowed to significantly enhance a waste by reducing the environmental impact that it would entail if disposed of inappropriately.

11.1.3 Limitations

Limitations are related to the initial concentration of indium in ITO glass, which strongly influences the economic sustainability of the developed hydrometallurgical process.

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11.2 Exploitation strategy

UNIVAQ intends to exploit this technology in collaboration with the internal partners as EuroLCDs, with the aim of linking the recovery of indium with the recycling of liquid crystals. Links with other partners as ILSSA and POLLINI are identified to promote this added value in the automotive sector.

11.2.1 Exploitation routes and guidelines

The commercialization of the innovative process for the recycling of indium is closely related to the automotive sector. Cooperations with the recycling companies/dismantlers such as ILSSA and POLLINI allowed to practically demonstrate the benefits and the validation of the process. WP6 activity related to the validation of the process at pilot scale will be essential for a successful exploitation. Therefore, the hydrometallurgical pilot plant, reconfigured under the TREASURE project, also serves also as demonstration purposes.

11.3 IPR strategy

11.3.1 Background IP access and ownership

The proposed process was developed within the TREASURE project. Skills and knowledge of UNIVAQ in the hydrometallurgy sector were used to create the process. UNIVAQ already holds several patented methods for treating different types of waste.

11.3.2 Foreground IP

Further issues related to the IP will be discussed after assessing the actual contributions of the other partners with whom the present ER is linked.

11.4 Exploitation risk management

Currently no exploitation risks are foreseen. They will define during the next months, after pilot scale tests.

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12. Exploitation plan: ER#9

Table 12. TREASURE ER#9 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
9	Recycling of silver from in-mold electronics	UNIVAQ	TNO, WALTER	Ink producers, Automotive dismantlers

12.1 Exploitable innovations and ambitions

UNIVAQ is interested in exploiting the results achieved within the TREASURE project in treating in-mold electronics (IMEs). In this sense, we want to enhance the hydrometallurgical process developed for the recovery of silver from IMEs. The process developed allows better management of this material at the end of its life, enhancing the raw materials contained. This aspect fits perfectly within the concept of the circular economy increasingly pursued globally.

Thanks to its excellent electrical conductivity, silver is a material that is widely used in electronics. Nowadays, silver ink printing technologies on flexible substrates are used in many industries. However, no work has been found in the literature that presents recovery processes or valorization of end-of-life IMEs. The proposed process recovers the silver in its metallic form. Evaluations on silver reuse as a precursor in ink formulation to produce new IMEs will be conducted during the project.

12.1.1 Technical description

This new technology consists of dissolution of silver in two steps followed by electrolysis. The leaching process is performed within an acid solution at ambient conditions using sulphuric acid, thiourea and ferric sulphate as reagents. This system is applied directly on IMEs without a pre-treatment. The procedure is performed for about 1 hours per step at a solid concentration not larger than 20%. At the end of the first step, the separation of the leaching solution from the residual solid is carried out. The residual solid is sent to the second leaching step. The residual solution, after filtration, is reused in the second step with the make-up of reagents. Further filtration is then performed to separate the solid from the leach solution. In leaching, thiourea acts as a complexing agent, while Fe^{3+} as an oxidant. This combination allows for effectively complex silver. The final solution is subjected to electrolysis to allow the deposition of silver on the cathode and then its recovery as a metal powder.

The reactions involved in the leaching process are as follows:

$$Ag + 3CS(NH_2)_2 + Fe^{3+} \rightarrow Ag\,[CS(NH_2)_2]_3^{+} + Fe^{2+} \quad (1)$$

$$2CS(NH_2)_2 + 2Fe^{3+} \rightarrow (SCNH_3)_2 + 2Fe^{2+} + 2H^{+} \quad (2)$$

$$(SCN_2H_3)_2 \rightarrow CS(NH_2)_2 + NH_2CN + S \quad (3)$$

The reactions involved in the electrolysis process are as follows:

Cathode

$$Ag\,(CS(NH_2)_2)_3^{+} + 3e^{-} \rightarrow Ag + 3(CS(NH_2)_2) \quad (4)$$

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$$3FDS + 3H^+ + 3e^- \rightarrow 3CS(NH_2)_2 \quad (5)$$

Anode

$$2\,H_2O \rightarrow O_2 + 4\,H^+ + 4e^- \quad (6)$$

Figure 9 shows a simplified diagram of the developed process.

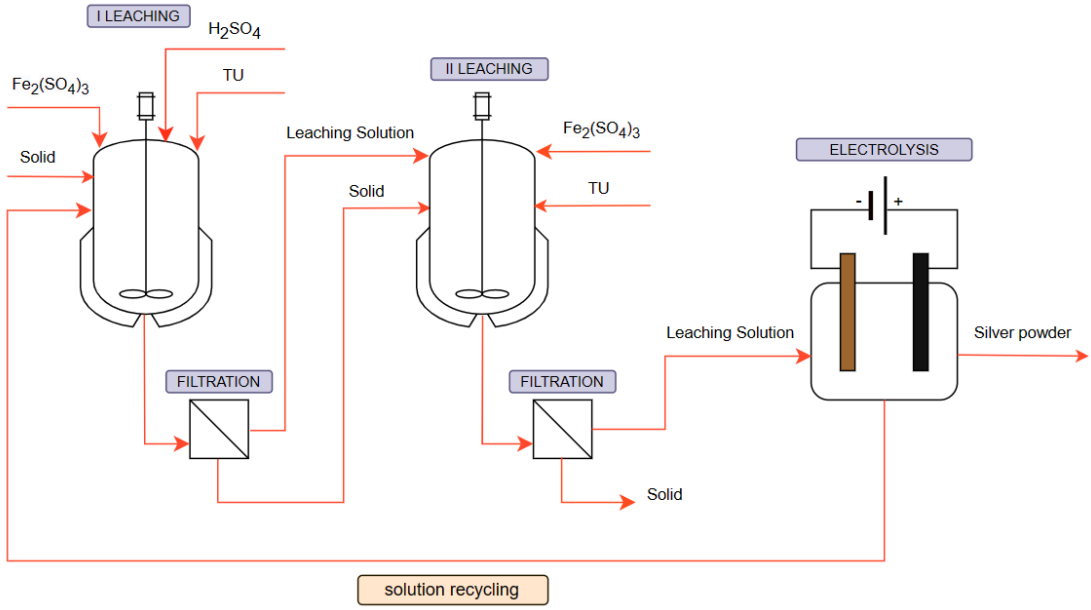

Figure 9. Simplified diagram of ER#9 process

12.1.2 Innovation properties and benefits

The developed hydrometallurgical process has an innovative content although a continuous optimization is in progress. There are no patent processes on the market for the treatment of end-of-life IMEs. The developed process makes it possible to recover valuable raw materials and re-enter them on the market, generating profits. In this way, it is possible to significantly enhance a waste with a high intrinsic value, reducing the environmental impact that it would entail if disposed of inappropriately. As regards the size of the profits, a scenario with 125 tons/y was analyzed, and it was seen that there are very advantageous PBP and NPV. Since there are no limits due to competing processes, the production capacity could be considerably higher with improvements in the above indices.

12.1.3 Limitations

Currently, any potential limitation of the innovation has been considered.

12.2 Exploitation strategy

The idea of UNIVAQ is to commercialize the process for possible investors. The process could be granted as a license or as a complete process engineering, providing the turnkey plant and the license.

12.2.1 Exploitation routes and guidelines

UNIVAQ will expect to define a detailed route and timeline in the next months.

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12.3 IPR strategy

12.3.1 Background IP access and ownership

The proposed process was developed within the TREASURE project. Skills and knowledge of UNIVAQ in the hydrometallurgy sector were used to create the process. UNIVAQ already holds several patented methods for treating different types of waste.

12.3.2 Foreground IP

In the coming months, the creation of a PCT patent will be evaluated. Limitation about this patent has not been yet discussed in the ambit of Consortium.

12.4 Exploitation risk management

A list of identified risks is reported in Table 12 to assess their risk grade according to the risk matrix.

Table 13. ER#9 identification of risks

no.	Description of risk	Probability of occurrence	Potential impact	Risk Grade
Technological Risk Factors				
1	Technical problems associated with the scale-up of the process from laboratory scale	high	medium	high
2	Decrease in the market price of silver	low	medium	low
3	Increase in the market price of the chemicals used in the hydrometallurgical process	medium	medium	medium
4	High disposal cost for the solid process output management	medium	high	high
Market Risk Factors				
5	Silver is replaced by another conductive metal for IMEs ink	low	high	medium
6	IMEs are being replaced by another technology in the automotive sector	low	high	medium
7	A more competitive process is developed	high	low	medium
8	No IMEs collectors found	high	high	crucial
IPR/ Legal Risk Factors				
9	New patents are issued recently in the same field	low	medium	low
10	The patent application is rejected	low	high	medium
Financial/Management Risk Factors				
11	Weak exploitation plan	low	high	medium
Environmental/ Safety/ Regulation Risk Factors				
12	Limitation in the use of the process chemicals	low	high	medium
13	Restrictions in the authorization for plant building	medium	medium	medium

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For some of the identified risks the mitigation actions have been highlighted below:

- No. 1 – to carry out pilot scale tests, for example using the TREASURE hydrometallurgical pilot plant, to reduce the scale effect from the lab to an industrial plant.
- No. 3 – to identify alternative chemicals.
- No. 4 – to identify a valorization route for the plastic/solid process output.
- No. 6 – to use a properly mill to obtain a powder with a particle size below to 2 mm.
- No. 12 – to identify alternative chemicals.

13. Exploitation plan: ER#10

Table 14. TREASURE ER#10 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
10	Recyclability analysis and recycling rate calculations, design for recycling feedback/advice	MARAS	none	OEMs, recycling industry, disassemblers, NGOs, policy makers

13.1 Exploitable innovations and ambitions

13.1.1 Technical description

Innovative recycling process simulation models have been developed and applied by MARAS within the TREASURE project. These models have been advanced, extended and further developed based on existing know-how and developed simulation model-based recycling assessment methodology as developed and applied by MARAS over years. The recycling simulation models are developed and applied to assess the full circularity of the end-of-life stage of car (electronic) parts and products.

This simulation-based methodology can be applied for the assessment of the recyclability of car designs, car part recycling performance, EoL system assessment to truly quantify and support CE in the Eol phase of products.

The figure below is a visual summary of the simulation-based approach used to determine the recycling rate of the different car parts and assess the full recycling system. The recycling simulation models cover the full recycling and metallurgical processing flowsheets for all best available techniques for metallurgical and final treatment recycling processing which exist in industry. These different recycling infrastructures are presented by the segments of the Metal Wheel (in the middle). Detailed flowsheets for each of the processing routes are covered in full process detail in the recycling system model, which provides a digital twin of (metallurgical) recycling industry. The flowsheet model used for this simulation-based approach is based on industrial economically viable processing (see Figure 9). It contains all unit operation in the various processing routes (in this stage 190-unit operations) and ca. 310 materials and compounds as can be present in the car parts and produced by the flowsheet as well as over

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840 streams for all phases including metals, molten flows, aqueous, dust, slimes, slags, calcine etc.

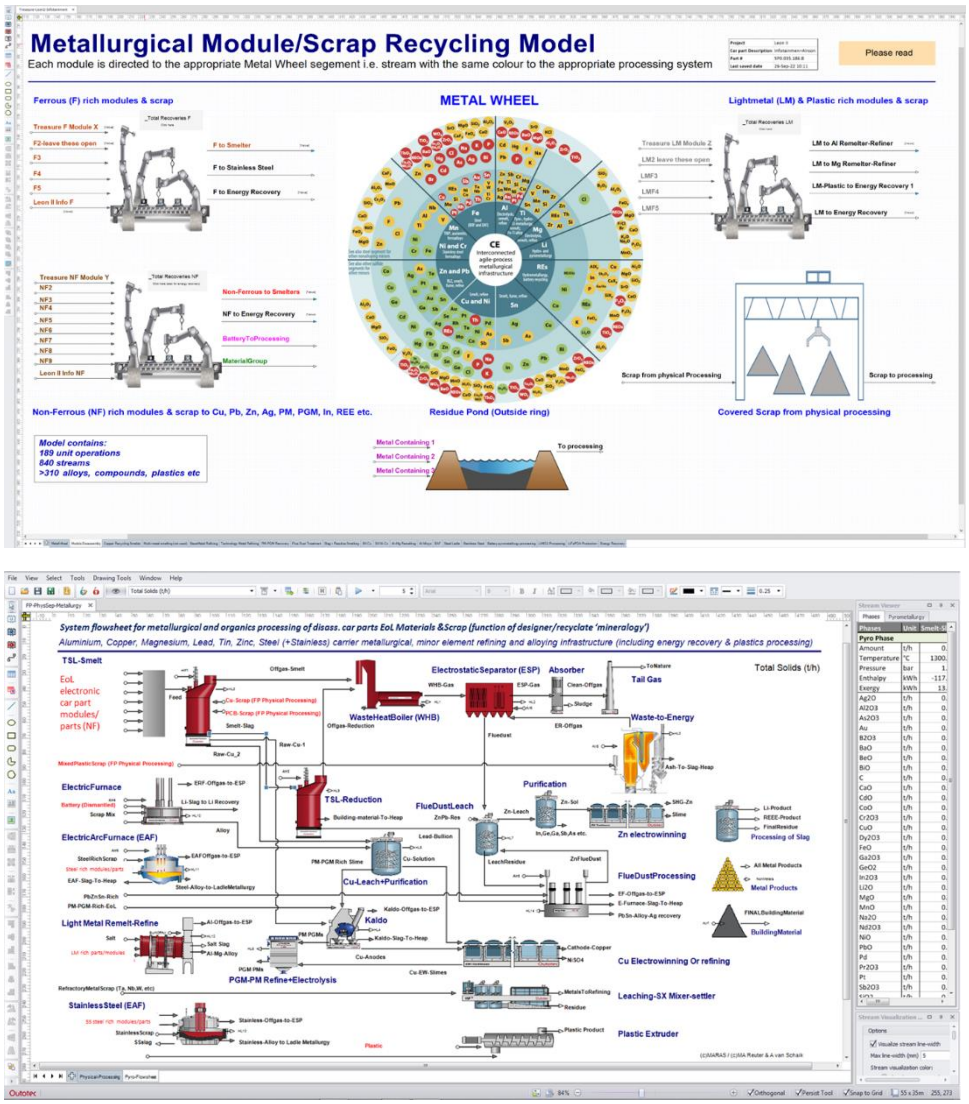

Figure 10. Summary of the simulation-based approach used to assess the full recycling system

The process simulation models have been developed in the industrial software platform HSC Chemistry Sim® 10 [6], providing a professional and industrial platform for process simulation tools and recycling as well as environmental impact calculations.

Recycling rates of the car parts for the total car parts/products as well as for all materials/compounds/elements composing the car parts are calculated on this basis for true circularity, i.e. recycling into materials with a quality that can be applied in the same product (closed loop CE). The assessment of the recycling system can be performed by the application of recycling flowsheet simulation modelling.

a. KPI's on recycling/recovery for whole parts/product as well as for individual elements/materials
    i. Total recycling rate (% and mass)

[6] www.mogroup.com

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ii. Individual material recycling rate of all materials/elements/compounds included in the car part (% and mass)
iii. Energy recovery in MWh/t of feed or per car part

b. Recommendations/advisory on most optimal recycling flowsheet architecture (based on the best available technologies at industrial level) – this will differ per car part and disassembly level.
c. Feedback/advisory to dismantlers on additional disassembly or the effect thereof to optimize recycling.
d. Design for recycling assessment and advisory: feedback and input to eco-designers based on metallurgical incompatibilities (qualitative from the Metal Wheel) and quantitatively based on the findings of the recycling simulations and derived insights into recoveries and losses of materials/elements/compounds of these car parts

This approach flows into the TREASURE platform tool (REC and ECO module and advisory).

The expert knowledge and process simulation model provide the basis for exploitation by providing consultancy, calculations and advise for the EoL phase of products as well as for DfR and optimal design of recycling systems (including balancing disassembly with recycling processing).

13.1.2 Properties and benefits of the innovation

The innovation provides digital twins for EoL stage for simulation-based analysis of metallurgical and recycling systems to assess the recycling and circularity of car electronic parts and disassembly combined with most suitable processing to optimize recovery of both CRMs as well as all other materials/compounds/elements as present in a product or part. This approach can equally be applied to any other (complex multi-material) (EoL) product and to design optimal recycling system configuration to realise CE at the product EoL.

The developed methodology allows for the definition and calculation of recycling KPI's and CE indicators. It provides a physics and industrial recycling technology-based feedback for EoL circularity assessment and advice (i.e. for TREASURE tool). Circularity can be quantified, visualized and is made tangible by application of this approach and innovation. By providing insights into all parameters affecting the recycling of a product or part, and pinpointing critical issues in recycling or design, these tool provide a rigorous physcis based framework to truly realise and optimize CE from an EoL product perspective. It also allows for optimization of the recycling system performance by linking different actors in the recycling system in analysing and optimization of the recycling system for different objectives and KPIs.

Recycling model and results are basis for REC (and ECO) module in TREASURE tool and can be exploited for recycling and Design for Recycling / Eco design advise for a wide range of products and industries. It builds a strong link between different stakeholders in the design and recycling system, by linking product compositional data (CAD, MISS data files etc) to recycling performance.

Innovative aspects are the Innovative physics and industry-based recycling simulation that provides a digital twin of recycling to assess and improve the unique recycling fingerprint of product/parts expressed in engineering-based recycling KPIs and CE indicators. True circularity in recycling system design and design for recycling can be supported by maintaining the material and energy quality for use in the same part and the quantification thereof. This approach provides a basis to use of AI to capture rigorous simulation information in more fastforward

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tools such as the TREASURE platform. It provides at the same time the basis for exergetic (2nd law of thermodynamics) system analysis for rarity of elements and recycling and environmental performance of the EoL system. It brings engineering industrial reactor & system design together to estimate circularity performance.

13.1.3 Limitations

No limitations are defined for the exploitation of this ER for consultancy, assessment and/or advice for different end users.

The only current limitation is the availability of sound and in depth product data on product and part composition build up and design, that is required from OEMs and part producers/suppliers in order to assess the designs and their recycling performance. This is however intrinsically part of true circularity and industrial recycling assessment and advice. The rigor of the processes, simulations tools and calculations should be equally met with detailed design data. The manual processing of product data to match with the level of detail which is required by thermodynamic process simulators are labor-intensive at this moment. However, guidelines and clear formats and instructions are developed from the recycling simulation tools and know-how to guide and instruct this data management and data format in order to link CAD design data with process simulator in a (more) automized way.

13.2 Exploitation strategy

13.2.1 Exploitation routes and guidelines

The exploitation of this ER is the application and where possible/required, further advancement of the recycling simulation models, for the assessment of recyclability, design of recycling systems (including modular design and disassembly driven novel approaches to recycling), DfR advisory for OEMs, part producers, recyclers, NGO's/collective systems for recycling of automotive and WEEE appliances etc. This can be exploited in selling consultancy services for assessment and advice. The methodology can also be applied for policy development and evaluation of recycling and CE in the EoL phase of products.

13.3 IPR strategy

13.3.1 Background IP access and ownership

The rigorous physics based methodology and development of recycling simulation models to be applied over the entire recycling system, linking product design, disassembly with (metallurgical) recycling performance and the application therof for recycling system design, advice and design for recycling assessment and advisory is background IP of MARAS B.V. The various indicators (Recycling Index, Material Recycling Flower) and their visualization are background IP of MARAS.

13.3.2 Foreground IP

To be evaluated.

13.4 Exploitation risk management

No exploitation risks are foreseen.

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14. Exploitation plan: ER#11

Table 15. TREASURE ER#11 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
11	Iterated research tool on public perception of the procedures and processes related to recycling, ELVs and CE	EDGE	SUPSI, TXT, UNIZAR, ILSSA, POLLINI	Policy makers, design, industry and recycling professionals, students, scholars

14.1 Exploitable innovations and ambitions

14.1.1 Technical description

The Edgeryders' Semantic Social Network Analysis (SSNA) tool is based on the collection of data on a public forum, ethnographic processing and visualization in form of graphs. It provides timely insights and data with a considerable market value.

The tool is open source. The data management plan includes an ethical consent funnel that leads to data collection. The research is limited to the duration of the project.

The possible exploitation result is an ongoing iteration of the digital ethnography analysis after the end of the project, making it a standard part of the future TREASURE platform.

The longitudinal dimension added to the current research enhances the understanding of the social perception of recycling and circular economy practices in the automotive industry.

A platform generating revenue could provide sufficient funding for regular research updates. The mechanism by which this could be possible can include, but is not limited to, subscription mechanisms linked to percentages of the platform revenue, consultancy packages with specific case studies, dedicated workshops developing the initial findings. Consequently, there would be the potential to build a unique corpus of data generated by thousands of informants in a combination of an event-based ethnography and a public forum.

14.1.2 Innovation properties and benefits

Digital ethnography

Ethnography is a social science methodology that has evolved to describe cultures. It is well-suited to the task of surfacing hidden assumptions and biases. The innovative part in how we deploy ethnography is our integration of the digital element which enables the **analysis of large amounts of qualitative data** (corpora) and **improves the accountability of the process**.

Building on prior research done by our group in the field of digital ethnography, the mixed qualitative and quantitative methods approach used can lead to informed action planning. This methodology proved to be robust and rose the challenges of analyzing corpora with thousands of informants and tens of thousands of contributions. This proved valuable in the domain of public consultations (e.g., focused discussions with the general public) or for cooperation building in a strictly limited experts' field (e.g., recyclers working in specific domains of the ELV and CE).

Inclusiveness, transparency and adaptability to different levels of research.

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Inclusiveness derives from the nature of a public forum. Stakeholders and consumers engage and explore their needs, expectations and possibilities while providing information and support. They constitute an *issue public*. The concept harkens to the political philosopher John Dewey who believed that, in a democracy, *competent publics emerge in response to issues by which their members are affected*, where expertise is contested and the established frames for problem-solving have broken down.

Members of issue publics set out on a quest to inform each other about a given issue and how it should be framed, effectively rendering the participation in such a forum a public consultation. The analysis of this process and its fruits is an inquiry into the results of that consultation.

Our method is based on the representation of ethnographic data as networks of co-occurrences between codes. It provides *trustable data analysis* through with better built-in accountability than traditional ethnography possesses, and more epistemological humility than is typical of big data analysis.

Data structured in digital form (including metadata describing how, when and by whom they were collected) and a partially algorithmic analysis provide also a greater degree of accountability than standard ethnographic practice. The digital element introduces simple verification processes (e.g., inducing a co-occurrence graph and calculating that graph's statistics are easily verifiable steps).

14.1.3 Limitations

Such ethnographic research connected to data science is not replicable (and is not expected to be replicable). Because of this, it has developed a culture of epistemological humility which includes the refusal to claim objectivity, transparency around the researchers' biases and assumptions encoded in positionality statements, and the tradition of involving informants in the analysis of the data they provided (c.f.Jean Rouch's "shared ethnography"). We argue that this, in a good measure, remediates the opacity of big data study.

An obstacle emerges from the fact that ethnography does not have a tradition of open science practices. Publication of data is rare, publication of FAIR data even more so. Data analysis remains a black box in most ethnographic studies. This means that ethnographic research could be made even more accountable and trustable by leveraging the digital nature of the mixed methods we advocate to embrace open and citizen science practices.

14.2 Exploitation strategy

The research conducted under the TREASURE project up to this point showed that there is:

a. An under-recognition of the concept of "circular economy" in the public interested in cars. People primarily associate it with concrete material practices (recycling behavior, parts modification, parts repurposing).
b. Personal networks of knowledge and expertise are linked to the practices of car maintenance, which is important to consider for industrial ecologists focused on human behavior. A deeper degree of analysis, combined with its development over a longer time period, would offer new insights usable in policy making, design and industrial implementation.
c. There is a high degree of conditionality in people's narratives of their behavioral choices contributing to (or working against) sustainable initiatives or participating in a circular economy of the automotive industry. Hypothetical scenarios such as "I would do X under

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these conditions" or "If it weren't for Y, I might purchase this kind of car" should be explored in practice, with the goal of gaining an increasingly granular understanding of the parameters of such conditionalities, as they are important and actionable in understanding and shaping consumer practices.

The commercialization and the exploitation strategy are yet to be defined in detail.

The basic process does not differ from the research done during the project. The steps involve community building, open conversation in written or oral form induced by dedicated events, ethnographic coding of the collected data, visualization of the nodes and reporting on the findings. The possible directions of topics to explore in an ongoing way include: the exploration of the commodity chain, life cycle assessment, scale.

As described, there are two possible directions of development:

a. one for the public consultation usage, providing data elements of social perception,
b. the other for the specialists' discussion, providing a participatory space for problem solving purposes.

The proposed tool can be tested within the TREASURE project environment to understand the additional benefits and compatibility with the TREASURE platform.

14.3 IPR strategy

SSNA methodology and the tools for its implementation have been developed by Edgeryders. The terms of use and privacy policy, linked to the Creative Commons license, are described on Edgeryders website[7].

14.4 Exploitation risk management

Currently, an element of risk lays within the domain of the GDPR. The state-of-the-art practices are adopted to implement the highest ethical standards. Potential risk level will be evaluated as the work on the ER proceeds.

15. Exploitation plan: ER#12

Table 16. TREASURE ER#12 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
12	Sustainable IME products	Walter Pack	TNO, COVESTRO, GENESINK	Car owners

15.1 Exploitable innovations and ambitions

15.1.1 Technical description

Sustainability is a hot topic in the automotive industry right now and WALTER PACK's, as a company operating on the automotive market, approach to the TREASURE project, has been one of trying to be ahead of the market in terms of sustainability. In 2023, the European Union announced that a law was to be enforced where all carmakers had to eliminate the use of fossil fuels to power car engines by 2035. This has been accompanied a set of measures also taken by

[7] https://edgeryders.eu/t/terms-of-use-and-privacy-policy/44

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the EU where they require car manufacturers to comply with several guidelines including reducing the carbon footprint of producing a car or the recyclability of itself.

These laws and trends where the final customer actually cares about sustainability and the caring for the planet, has caused a big turmoil in the market, causing all players in the industry to have a bigger focus towards these topics and stop producing solely on productivity and cost. For these reasons, in this project we have challenged ourselves by creating a very complex and integrated product recyclable, or at the very least sustainable.

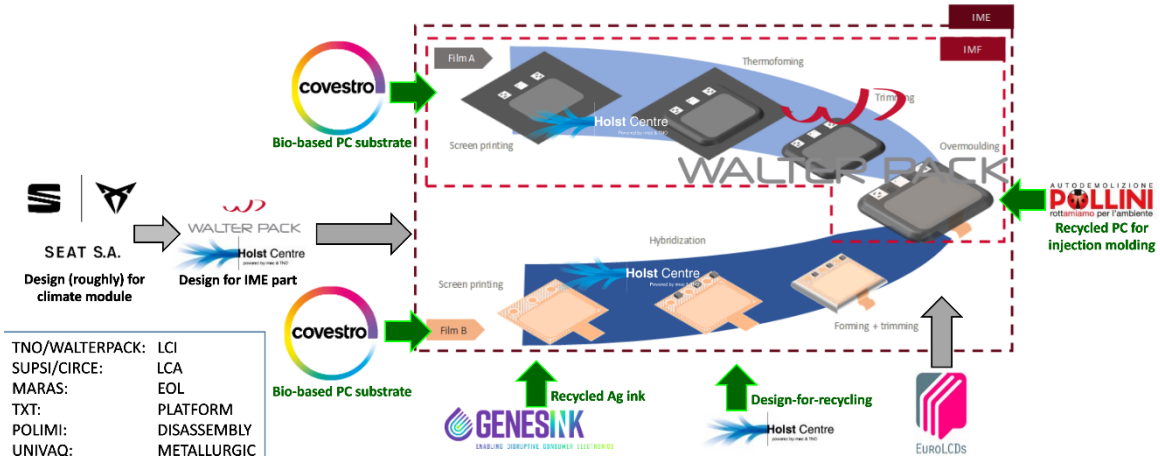

Figure 11. Diagram showing the process flow of the final IME demonstrator

In the figure above it can be seen what has been put forward as final demo for this project. This of course implies creating a new product for an already rather new technology, which is IME. The IME technology consists on having a double purpose part, be injection moulded without the additional processes of gluing, taping or stamping. The double purpose of the part is coming from the fact that the technology allows to integrate function into a decorative part, all at once.

Creating an IME is challenging in it of itself, let alone be it sustainable and recyclable, but this has been tackled during the TREASURE project. The premises with which we have worked are the following:

a. Plastic materials: Reuse them from a recyclable source (if it is coming from the own waste produced at WP even better). Alternatively, if this is not an option, the product could be made more sustainable overall if the materials are bio-based.
b. Silver ink: One of the key elements of this project is that the silver ink used to print the conductive features, will be coming from recycled IME parts provided, empowering the circular economy.
c. Design for recycling: The part will be designed in a way that the whole construction of the product can be disassembled, creating a part that is ready to be recycled, given the correct instruction. However, this is where the TREASURE platform would be very beneficial.

Through these improvements, we would to add sustainable value to our customers, creating a product that is up to date, complex, technological and sustainable. Exactly the kind of product that anyone would like to exploit.

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15.1.2 Innovation properties and benefits

As explained in the previous paragraph, the product created will create a lot of benefits. The idea portraited is to create a product that has a reduced carbon footprint, which will help comply with future regulations and specifications coming from car makers. The concept of eco-design is very important here, as one of the key properties of this product, which will greatly influence the exploitation strategy. Eco-design implies that the product must be designed with a sustainable mindset, always with sustainability as a driving force. This usually requires the customer to involve their suppliers in the process, activity that we think as key to have success, since it will be us the ones that we will know how to integrate the sustainable bits and pieces into the final product, therefore a collaboration between customer and supplier is mandatory for this work out.

Obviously, this activity brings a very clear advantage in terms of sustainability by making the product recyclable, reduce waste and reuse our own waste. However, the benefits do not stop there. It is possible to spare some costs in raw materials or even make business by selling disassembled materials that can later be reused for another purpose. This is really the potential of recycling.

Finally, I would like to mention how the target of Europe is to make the world a better place for everyone and especially for future generations. If this position is ever to stand worldwide, then in Europe we would have an edge over the Asian suppliers which are right now driving the industry in Europe back slightly. Since their focus is clearly in technology instead of sustainability, the hope is that someday this will become a rule between nations and a common agreement, in which case we would be ahead compared to the knowledge of this topic overseas.

15.1.3 Limitations

The biggest drawbacks right now when adopting sustainable measures to new products, is the performance of the materials. Although the market is able to deliver more sustainable materials, the performance and properties of them is not yet up to the level of the more traditional plastics coming from fossil fuels. This applies not only to raw materials, but also to the modifications made to the product itself to allow disassemblability. Performance and properties refer to mechanical properties and behavior to the several automotive tests that a part needs to undergo in order to validated and to be compliant with the OEM specification.

A second point that mas be heavily considered concerns the recycled materials to be used. The source of the recycled materials must be controlled, as there are some materials which's mechanical properties deteriorate when gone through several recycling cycles. This means that some materials have only a limited number of times that can be recycled in order to be in the correct condition to be used in a car.

15.2 Exploitation strategy

The exploitation strategy is focusing mainly on trying to share our knowledge with OEMs and show them our knowledge in order to include a product of the characteristics of the one that we are doing in the TREASURE project, in the next generation of cars. Our objective is to produce this type of parts in serial production, therefore the strategy would be to create a marketing plan that includes de following elements:

a. Online communication of the feats and results of the TREASURE project to show what WALTER PACK production and product capabilities
b. Arrange physical meetings and tech days to show and demonstrate demos

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After the marketing plan has been successfully carried out, then the phase of design starts. It is key for eco-design that the contact with the customer is made early in the product development phase in order to take into account the premises on design for sustainability to develop a product which is as environmentally friendly as possible.

15.3 IPR strategy

Not applicable.

15.4 Exploitation risk management

Currently no exploitation risks are foreseen.

16. Exploitation plan: ER#13

Table 17. TREASURE ER#13 details

No.	ER title	Lead partner	Link with other partners (internal and *external*)	End Users
13	TREASURE Platform	TXT	MARAS, SUPSI, SEAT, UINZAR	Dismantlers, Recyclers, Car manufacturers, Car components suppliers, Car designers, Shredders

16.1 Exploitable innovations and ambitions

TREASURE Platform is one of the main outputs of the project, being the digital vehicle to transfer knowledge produced during activities execution and deriving from the analyses performed by tools owned by partners involved in WP4 tasks. TREASURE platform aims at becoming a reference tool for the circularity assessment in the automotive sector by sharing essential information among the stakeholders of the value chain. Since TXT is the only IT provider in the Consortium and platform creator/administrator, the application represents the main exploitable results for the company.

16.1.1. Technical description

TREASURE platform is conceived as an information system that provides intelligence to BoL (dismantlers/shredders, recyclers) and EoL (car manufacturers, 2-3 level tier manufacturers, car designers) actors in the automotive value chain to improve car electronics circularity. The technological solution works as a knowledge catalyst that brings together data coming from different sources (external database, CAD files, user feedbacks, involved uses cases/expert prior knowledge) used to perform CE assessments from an environmental, social and economic perspective. The platform is designed as a digital toolbox based on integration of partners applications (MARAS Recycling Simulation Tool, SUPSI Sustainability Assessment Tool) in an inclusive digital environment. This allows to perform circularity analysis according to specific KPIs providing aggregated information on:

a. Disassembly procedures

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b. Recycling routes and assessment

c. Eco design recommendations

The platform is complemented by the Circular AI-based Advisory module that supports BoL and EoL actors in the decision-making process for each scenario based on the Sustainability & Circularity Advisory methodology.

Thus, the platform main activities involve data ingestion and handling based on the key resources involved in the information flow that concerns two major elements, revenues and costs. These aspects, complemented by the knowledge coming from open/closed databases, guide all analysis performed within the project affecting the results provided to the user. Regarding the revenues, the data collected and processed by TRASURE application refer to car part material composition, market value, the financial gain from different recycling routes determined by total and individual recovery rates. If we consider the costs, the information provided regards dismantling time and difficulty and the expenditures incurred in different recycling routes determined by total and individual recovery rates. The combination of both costs and revenues metrics drive the data elaboration taking into consideration TREASURE value proposition as information system providing intelligence on car electronics composition and recyclability.

To this extent, the platform relies on cooperative relationship with specific key partners that involve not only MARAS, as internal entity part the consortium, but also external actors. As for the former, the platform integration with the Recycling Simulation tool is essential to perform recovery studies that determine the recycling routes shown by TREASURE application. As external partners, a relationship with closed database owners (such as IMDS) is strategic to access high-detailed information on material composition that is stored in TREASURE data lake. Moreover, the tier components suppliers can also be involved in data sharing to improve the knowledge basis.

16.1.2. Innovation properties and benefits

TREASURE Web Circularity platform serves as a key technological enabler that connects the three processes (Disassembly, Recyclability and Eco-Design) investigated in TREASURE project. The integrated platform is a toolbox made up of 3 application modules supporting information and knowledge exchange for both BoL and EoL stakeholders in the automotive sector. The value proposition of TREASURE digital solution consists in providing a platform that gathers a wide range of information on electronics in different car components from different perspective depending on the user's scope. This is the starting point for the identification of the potential customers segments: from one side we have the EoL stakeholders that consist in dismantler and recyclers while from the other the BoL, meaning car manufacturers/designer or tier suppliers, are involved.

For the former, the added value of TREASURE platform is evident in the Disassemblability module where key knowledge related to disassembly time and costs is provided and used to define the most convenient dismantling procedures according to the two previous elements. The outputs of this analysis contribute to improve operations efficacy while efficiency is addressed via AR/3D application use. Through the WEAVR player application, the blue collar operator can follow step-by-step the dismantling process with a beneficial impact on costs decrease and operations speed up.

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In the case of the recycler, the Recyclability module of TREASURE platform supports industrial actors and WEEE professionals in identifying the recovery rate of a specific category of materials taking into consideration different industrial processes and disassembly levels. The platform displays both total and individual recycling index based on advanced recycling flowsheet simulation models, supplied by the Recycling Simulation Tool. According to user's objective, the data provided by the module enables the assessment, quantification and optimisation of recycling routes and EoL circularity process. This analysis is then complemented by the social and economic impact assessment performed according to the Sustainability & Circularity methodology developed by SUPSI. Thus, the user is able to access aggregated intelligence processed considering the three dimensions (environmental, social and economic) to gain a comprehensive insight on recycling routes impact.

If we consider the BoL perspective, the platform value is provided in the Eco-Design module where the user can visualize eco-design recommendations, based on specific metrics (thermodynamic rarity, metal weight, plastic characterization, disassembly KPIs) and the evaluation process performed by dismantlers and recyclers. Thus, the knowledge collected from databases and users feedback supports car manufacturers and component suppliers to improve car parts design from a CE perspective. Moreover, the user is able to assess the compliance of the car component design to specific guidelines elaborated according to dismantlers and recyclers inputs and academic knowledge in the field. This process can be performed not only on an already existing car part design but also on an hypothetical model layout created by the user.

16.1.3. Limitations

TREASURE platform is design to provide information on circularity, ensuring product flexibility to adapt to different contexts and customer needs in the automotive sector. Given the project scope, the application is validated in the SEAT use case considering data related to a specific car model. This will serve as a standard for the automotive field defining a reference framework for recycling processes and circularity adoption that any potential user can apply to a specific use case. This implies that the user should have an expertise in the CE and automotive domain to assess the suitability of TREASURE platform to the case study. Moreover, the access to specific information contained in closed database is essential for the platform replication on a larger scale. The fact that the application potential customers consider a wide range of actors in the automotive value chain implies a strong market segmentation planning different commercialization approaches.

16.2. Exploitation strategy

The exploitation plan is affected by the key elements of the TREASURE platform business model presented in the previous sections. The costs' structure and revenues streams impact on the strategy definition contributing to define the commercialization plan in terms of product offering and time to market. Regarding the costs structure, the following key elements are considered: expenditures related to R&D activities to ensure the platform ongoing technical improvements; maintenance costs, including cloud costs (ex. AWS, Amazon Web Services); technical customer support; staff effort for 3D/AR dismantling procedures creation; and closed data sources access fees.

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Based on the potential costs and value proposition, the revenues will be originated from a subscription fee paid for knowledge transfer granting the user access to relevant information on car components/electronics, recovery rates to determine recycling routes, key data for dismantling operations planning, recommendations for including recyclability in the design phase.

For a more detailed study for circularity implementation, expert consultancy will be foreseen as an additional service package providing a professional support in identifying the optimal configuration of recycling process and implement it according to customer needs. This is based on two assets:

a. The recycling models elaborated by MARAS Recycling Simulation Tool that can be exploited for recycling and Design for Recycling / Eco design advise for a wide range of products and industries. The Innovative physics and industry-based recycling simulation provides a digital twin of recycling to assess and improve the unique recycling fingerprint of product/parts expressed in engineering-based recycling KPIs and CE indicators.
b. The socio-economic and environmental impact assessment based on the Sustainability & circularity Advisory methodology. Thanks to this asset, the consultancy services focus on the implementation of more sustainable and circular practices by maximizing the extraction of materials from end-of-life components and reintegrating them into the production cycle through recycling. In addition, it serves as a guiding framework to assist in the design of electronic components with improved sustainability and circularity characteristics, also facilitating future disassembly and recycling processes.

Finally, a third service package is considered with respect to 3D dismantling procedures design and implementation via AR/VR application. This revenue stream is conceived as a pay per use service exploiting WEAVR platform, 100% owned by TXT. The service can be used for training purposes to improve disassembly operations efficiency.

Given the value proposition, the customers engagement strategy will focus on long term B2B relationship due to the investments needed for set up and the client need to use the platform for a multi-year period (for example to implement recycling processes or design sustainable car parts). For this reason, the channels used to customer reach mainly involve attendance and presentation at sectorial fairs and events, exploitation of already existing customer or prospects lists to disseminate TREASURE platform business value.

Being an iterative process, the commercialization strategy is yet to be defined in detail and will be updated according to the technical enhancements performed during the platform second release.

16.3. IPR strategy

The IPR strategy is linked to the exploitation strategy as exploitation proceeds via licensing, consultancy and tech/prototype development using obtained IP. It is defined in accordance with the principles agreed in the Consortium Agreement concerning open-source licenses handling, IPR management and protection at project level, ownership of foreground and access to background. At this stage, the IPR strategy is not defined yet since it depends on the technical evolution of the platform second release. The strategy will take into consideration the IPR plan

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for other assets involved in the platform, such as ER#10, ER#5, #ER14, which will be probably sold as added services linked but separated from the core platform.

16.3.1. Background IP access and ownership

Within TREASURE platform the involved background mainly concerns WEAVR platform, 100% owned by TXT. In particular, the WEAVR player application is exploited in the creation of dismantling procedures in 3D or AR. This application is a proprietary product with a closed access available only as a pay-per-use service.

16.3.2. Foreground IP

The foreground developed within TREASURE platform consists in the Sustainability & Circularity Advisory based on the methodology defined as ER#4.

16.4. Exploitation risk management

A list of identified risks is reported in table below to assess their risk grade according to the risk matrix.

Table 18. ER#13 identification of risks

no.	Description of risk	Probability of occurrence	Potential impact	Risk Grade	Mitigation Action
Technological Risk Factors					
1	Unexpected technical problems leading to system failure	medium	high	high	Implementation of a recovery plan
2	Security breaches or data leaks	low	high	medium	Implement a strong cybersecurity protocol
3	Integration of new features to meet customer needs	low	medium	low	Flexible platform design that facilitates new modules/features implementation
4	Data obsolescence	low	low	low	Ensure a constant data update based on information collected from external databases
5	Unexpected integration problems if other partners tools change configuration	low	high	medium	Implementation of a strong communication system with other involved partners to anticipate changes
Market Risk Factors					
6	Slowed market adoption due to customer perception of the platform as not strategic for business	medium	medium	medium	Strengthen the marketing strategy to stress platform value proposition
7	Financial barrier due to initial investment considered too expensive	medium	high	high	Provision of different pricing strategy

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8	Delay in time to market	low	low	low	Accelerate technical development and validation phase
IPR/ Legal Risk Factors					
9	Impossibility to access closed database	Low	high	medium	Build a strong relationship with database owners
Financial/Management Risk Factors					
10	Occurrence of unforeseen costs	Low	medium	low	Accrue a financial reserve
11	Unexpected increase of operating costs	medium	high	high	application of a financial management system based on budgetary and cash flow control
12	Revenues stream insufficient	medium	high	high	Foresee new additional services to increase revenue sources
Environmental/ Safety/ Regulation Risk Factors					
13	Introduction of new policies in the automotive sector or circularity domain	Low	medium	low	Update of the developed standard according to new regulations

Potential risk level will be evaluated as the work on the ER proceeds.

17. Exploitation plan: ER#14

Table 19. TREASURE ER#14 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
14	Advice on recyclability of vehicle components and their disassembly methodology	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

17.1 Exploitable innovations and ambitions

17.1.1. Technical description

With this project, an extension of knowledge has been acquired in the recyclability of car part components, knowledge about how to disassemble them at different levels and how to prepare them to obtain the valuable and rare metals of which they are composed. This helps us not only to provide training on how to recover materials, but also to advise workers and clients of the ILSSA group.

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17.1.2. Properties and benefits of the innovation

The circular approach offers developed economies a path to stable and resilient growth, a response to reduce dependence on primary resources, and a way to mitigate exposure to resource price shocks. Furthermore, in this way, companies can successfully and to a large extent avoid important social and environmental costs. The circular economy will displace the use of energy-intensive materials and primary extraction. Emerging economies will be able to benefit from the adoption of the circular economy, by not being trapped by certain technological trends that condemn them to be captives of obsolete models that are poorly adjusted to their real conditions and needs. In addition to all the innovation value proposition allows us to offer the following:

Offers advice and consultancy on issues related to the recyclability and disassembly of vehicle parts.

a. What are the steps to follow in the process.
b. What are the necessary tools when disassembling the pieces.
c. How to get dismounting in the different levels.
d. What are the components that we can obtain and in what quantities.
e. Which are the companies to which the components can be offered.
f. Advice on eco-design for automobile companies.
g. Offer training to workers on the disassembly of parts.
h. Encourage workers' curiosity to disassemble other models than those made in the TREASURE Project.
i. Training for the commercial department to find markets to which to offer the recovered metals.

We can also offer the following benefits if advisory services are contracted:

a. Save of time and money.
b. Improved focus on core business.
c. Update with the latest trends.
d. Obtaining measurable results.
e. Provide comprehensive advice.
f. Identification of critical areas and improvement.

17.1.3. Limitations

The limitations are basically the following:

a. Parts for specific makes and models have been removed, but more research should be done on other makes and models.
b. The difficulty of obtaining information from car brands to access their information.
c. Obtain permission to disseminate brand information.
d. The collaboration of partners is needed in this project to be able to know what happens once ILSSA finishes its disassembly, communication between collaborators is needed.

17.2 Exploitation strategy

17.2.1 Exploitation routes and guidelines

The routes followed have been:

a. Choose the SEAT models for disassembly.
b. Decide which are the pieces that are going to be disassembled.

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c. Define which are the levels of disassembly of the pieces, tools used for their disassembly and times in which the tasks have been developed.
d. Identification of valuable and rare metals found in the pieces.

For the transfer of project results and to carry out their exploitation, the direct exploitation of results can be used. In this case, it would be the project partners themselves, owners of the results, who would directly carry out the subsequent development and exploitation. Through a dissemination strategy, understanding is facilitated by potential users, it links them throughout the life of the project to obtain their commitment to make it viable and to have an efficient exploitation of the results. According to the "Guide to Exploitation and Dissemination of Results" of the Botín Foundation, they must: evaluate the barriers to carrying out the project, facilitate the transfer of project results and commit to the project. Each of these points compromises others that are important to understand the best exploitation route and finally it must be understood that in order for the project to be properly disseminated, the three previous points must be well compromised, because only in this way it increases the possibility of reaching the target audience and making the process sustainable.

17.3 IPR strategy

17.3.1 Background IP access and ownership

Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has previous knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT. The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and number of rare metals, as well as information on assembly and disassembly of parts. If this limitation is extrapolated to possible business expansions with other car brands, the same thing can happen. Companies are very reluctant to share their data, so it is a touchy subject.

17.3.2 Foreground IP

ILSSA considers that intellectual property should have some guiding principles for its management:

a. Encourage staff for the creation, dissemination, and exploitation of R+D+I for educational, commercial, and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database
f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.
g. Promote the transparency of knowledge and R+D+I result to society and industry and its industrial and commercial exploitation.

In relation to the results that are of interest for their protection, dissemination and exploitation, ILSSA is responsible for:

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a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

17.4 Exploitation risk management

The risk associated with "Advice on recyclability of vehicle components and their disassembly" is characterized by the difficulty in transmitting knowledge from ILSSA workers to project member partners and/or third parties. This risk is defined by the need to transfer knowledge about the recyclability of vehicle components and parts, their disassembly, recovery conditions, methods for separating the resulting fractions, etc. This risk can be mitigated by carrying out the procedures of the processes, documenting the Know-how and standardizing the work methods to facilitate the transfer of that knowledge. For these reasons, the risk of events that prevents the transfer of knowledge is mitigated if the described measures are adopted. Project tasks 3.1 and 3.2 have largely served to mitigate this risk and will allow the knowledge acquired to be transmitted to third parties. For this reason, we must conclude that the risk of exploitation associated with advice on recyclability of vehicle components is low and its potential impact on the development of exploitation is low by adopting knowledge transfer protocolization measures.

18. Exploitation plan: ER#15

Table 20. TREASURE ER #15 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
15	Training and consultancy in circular economy	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

18.1 Exploitable innovations and ambitions

18.1.1 Technical description

ILSSA has been working in the world of recycling and waste for almost half a century. In these almost fifty years, he has been able to learn how waste management has evolved, how it has evolved from recycling to recovery and today the newest concept of circular economy.

Circular economy is a concept that has always existed, nature has done it naturally, but it is now due to necessity and a lack of materials and natural resources that we must use it and apply it to the current reality.

All the information collected can be transformed into training for the ILSSA workers themselves and potential clients interested in having knowledge or who require consulting in circular economy.

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Training in the circular economy not only provides the knowledge but also the necessary skills to be trained in a subject that not many companies are specialized in. European legislation requires that we be more aware of the circular economy and that we apply this concept to the development of companies in all areas.

18.1.2 Properties and benefits of the innovation

ILSSA information and experience is a very important power and value. All this knowledge can be transformed into the form of training and consultancy for those who want to delve a little deeper into what the circular economy means for their company. The circular economy represents a strategic tool of great value to redirect the current economic model with a responsible and intelligent approach to reject the culture of waste and speculation. The benefits that it brings to ILSSA and its workers who have training in circular economy are the following:

a. Providing training to workers improves knowledge and provides personal and professional growth.
b. All go in the same tune and therefore achieve the objectives in a joint way.
c. Improves the image of the company towards the client.
d. It can improve the economic growth of the company because it can save costs in raw materials or reduce them.

There are great advantages to offer circular economy training and consultancy to the automotive industries and to all industries and companies in any field for their own economy. Have the necessary knowledge in circular economy and apply it in companies:

a. Investigate more about how to improve production processes.
b. Investigate to make products more friendly to the environment.
c. Improves the competitiveness of companies. Knowing how the circular economy works and being able to apply it to their own company makes them reduce costs in raw materials, energy and water.
d. More and more users are looking for companies that produce in an environmentally friendly way, so the company's image will be better, and it will attract more customers.

18.1.3 Limitations

There may be certain limitations such as:

a. It is necessary to be in constant investigation and that supposes big economic costs.
b. The project has been limited to the automotive industry and only to certain models.
c. There is still no regulation that regulates the circular economy and that means that many companies do not want to adopt measures to catch up.
d. Lack of environmental awareness on the part of customers and suppliers.
e. Economic barriers and access to financing.

18.2 Exploitation strategy

18.2.1 Exploitation routes and guidelines

The concept of circular economy applied to the industry is quite recent, so the strategy is researching to get a main position. For this, it is necessary to have technicians and trainers who:

a. Know how to respond to the needs.
b. They must know the automobile market at the end of its life.

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c. Knowledge of the steps followed in the TREASURE project is advantageous when offering this training, since the entire process and steps developed are known.

For the transfer of project results and to carry out their exploitation, the direct exploitation of results can be used. In this case, it would be the project partners themselves, owners of the results, who would directly carry out the subsequent development and exploitation. Through a dissemination strategy, understanding is facilitated by potential users, it links them throughout the life of the project to obtain their commitment to make it viable and to have an efficient exploitation of the results. According to the "Guide to Exploitation and Dissemination of Results" of the Botín Foundation, they must: evaluate the barriers to carrying out the project, facilitate the transfer of project results and commit to the project. Each of these points compromises others that are important to understand the best exploitation route and finally it must be understood that in order for the project to be properly disseminated, the three previous points must be well compromised, because only in this way it increases the possibility of reaching the target audience and making the process sustainable.

18.3 IPR strategy

18.3.1 Background IP access and ownership

Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has previous knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA's closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT. The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and amount of rare metals, as well as information on assembly and disassembly of parts. If this limitation is extrapolated to possible business expansions with other car brands, exactly the same thing can happen. Companies are very reluctant to share their data, so it's a touchy subject. Before starting the project ILSSA is dedicated only to the disassembly of parts, this is the individual bottom protection in which it works.

18.3.2 Foreground IP

Foreground intellectual property is all knowledge produced within the collaborative enterprise or open innovation project during the life of the project. ILSSA considers that intellectual property must have guiding principles for its management and both the background IP and the foreground IP are governed by them:

a. Encourage staff for the creation, dissemination, and exploitation of R+D+I for educational, commercial and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database
f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.

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g. Promote the transparency of knowledge and R+D+I results to society and industry and its industrial and commercial exploitation.

In relation to the results that are of interest for their protection, dissemination and exploitation, ILSSA is responsible for:

a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

18.4 Exploitation risk management

The risk associated with "Circular economy training and consultancy" is characterized by the difficulty of knowing the different aspects in which an automotive company is involved and in satisfying the training needs they may have. A personalized training that in each company can be different and that is personalized according to the needs that the client has, considering the number of workers and the different departments of which the company consists of. A training in circular economy. As experts in matters related to the environment, waste management, recyclability, and circular economy, we can transmit this knowledge to those companies that want to improve all these aspects and apply it within their business environment and thus satisfy not only their business needs but also those of their own clients. This risk can be mitigated by preparing exhaustive, precise, and rigorous documentation on how to train workers on issues related to the environment and the circular economy, so that they are prepared for the challenges that the European Union and society, which is increasingly demanding with respect for the environment and thus provide a solution to the serious problem of lack of natural resources that we face worldwide. For this reason, the risk of occurrence of events is mitigated if a conscious preparation of rigorous training is carried out and therefore it can be classified as a low occurrence level and its potential impact is also low.

19. Exploitation plan: ER#16

Table 21. TREASURE ER #16 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
16	Knowledge of vehicle components and their composition to give the value and increase recyclability to improve the circular economy	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

19.1 Exploitable innovations and ambitions

19.1.1 Technical description

The purpose of TREASURE Project is to apply the circular economy in the automotive sector. Through the project it has been possible to know which are the most valuable components that

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we can find in car parts, for their recovery and subsequent reuse. Put aside the linear production processes and turn them into circular ones, which are much more beneficial for the employer, customers and above all for the environment. The rarer the metal, the higher its value, since they are scarce, but necessary to continue producing new cars. During the development of the TREASURE project, three SEAT models have been selected: Seat León II, Seat León III and Seat Ibiza IV. Of these models we have selected the following parts: combi instrument, infotainment, exterior mirrors, additional brake light, speed sensor, rain sensor and air quality sensor. Three levels of disassembly of each car part have also been determined. Level 1 refers to the disassembly from the car, level 2 refers to the disassembly of the main part to the smallest parts and level 3 refers to the disassembly of the smallest parts to the fractions to be recycled.

19.1.2 Properties and benefits of the innovation

The benefits of this innovation is the recovery of the following rare metals. In the following table you can see which the metals are obtained, their qualities and their uses in the different industries:

Tantalum (Ta):

Application industry	Description of qualities	Uses
Electronics industry	Store more charge per gran tan other metals.	Electrical capacitors and resistors.
Automotive industry	Ignitiion and transmisión sistemas with high temperature.	GPS and anti-lock brake systems.
Medical equipment	Biocompatibility capacity, does not produce toxic products	Medical implants and prostheses
Satellites and space industry	Good electrical storage capacity, minimal maintenance and low cost.	Decrease heat flux in spacecraft during planetary reintegration
Oil and Gas	Machinery and tolos are subjected to high temperatures and pressures.	High resistance to chemical attack.
Military and aerospace	Produce super alloys when mixed with specific metals.	Ability to withstand extreme temperature and stresses, such as those found in commercial and military aircraft engines. Higher internal combustión temperatures.

Gold (Au):

Application industry	Description of qualities	Uses
Electronics industry	The most important use of metal in industry	Manufacture of: mobiles phnes, calculators, watches, GPS systems, televisions, tablets, and cards, automobile electronic components (brakes and

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		ignition systems), contact, cables, switches.
Nanotechnology	For those elements that work with very small amounts of conductors and very thin in sheets, it does not produce corrosion and allows the conduction of small currents.	Nanotechnology products
Aerospace technology	Helps to prevent your elements from being damaged and improves work capacity.	Thermal insulation for weather satellites
Dental industry	Durable, castable, and corrosion-free properties.	Dental pieces, plates and fillings.

Zinc (Zn):

Application industry	Description of qualities	Uses
Galvanization	Prevents corrosion	Galvanizing iron for the automotive industry, electrical industry and hardware, electric vehicle batteries.

Copper (Cu):

Application industry	Description of qualities	Uses
Electrical industry and telecommunications	Electricity conductor	In the form of copper wire in the generators of power plants, domestic and industrial motors, domestic telephony and computers, houshold electrical installations, gas, household appliances.
Mechanical field	Thermal conductivity, tensile and fatigue resistance, easy molding and ease of joining by welding.	Radiators, industrial, wáter coolers, heaters, combustion engine parts and tolos, ship hulls, propellers, pipes and oil rig equipment.
Construction	Decoration element	Coating walls, interior frames, ceiling and other elements in construction.
Chemical industry	Agriculture applications.	Fungicides and disinfectants based on copper salts, copper sulfates and oxychlorides.
Health	Copper provides specific amounts of trace elements to keep us healthy, it is also antimicrobial and is a substance that serves to	Application to plants, animals and humans.

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	inactivate bacteria, fungi and viruses, helping to preserve youth and skin elasticity.	

Palladium (Pd):

Application industry	Description of qualities	Uses
Electronics industry	Excellent conductive properties.	Coating of connectors in electronic devices.
Automotive industry	Properties as a catalyst.. Allows to increase the speed in the cracking of oil, accelerates dehydrogenation processes.	Catalytic converter in gasoline cars and in machines with engines.
Robotics industry	They allow efficient transmission of electricity and reduce the generation of heat and therefore the loss of energy.	Electrode in ultilayer ceramic capacitors.
Dentistry and medicine	High resistance to corrosion. Due to catalytic properties of Palladium, this metal is used as a substitute for enzymes in synthetic biology, which has allowed the effective study of various pathologies. Antimicrobial properties.	Use on small metal plates to restore damage to dental crowns and brifges. In vitro experimentation with mammalian cells. Manufactures of surgical tools. Blood sugar test strips.
Renewable energy	Cold fusion. It is capable of absorbing a large amount of hydrogen, which allows it to be stored for later use in power generation.	Obtaining cheap atomic energy.

Magnesium (Mg):

Application industry	Description of qualities	Uses
Automotive industry	Magnesium alloys are used in the automotive industry in the manufacture of components, which give great resistance and shine.	Tires
Construction industry	Some magnesium compounds are very effective as refractory materials in furnaces.	Steel, iron, non-ferrous metals, portland cement and glass.
Mining industry	It has important salts with reducing properties in the mining industry.	Obtaining uranium.
Photography and Fireworks industry	Able to give off conspicuous light.	Manufacture of flash in cameras and mobile phones. Firebombs and Fireworks.

Nickel (Ni):

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Application industry	Description of qualities	Uses
Automotive industry	It has a very high level of alkalinity and high reactivity, allowing it to generate enough electrical current to start the electric motors in hybrid cars to put it into operation. Alloy with copper is very anticorrosive.	Batteries and rechargeable cells, hybride batteries for hybrid cars. Manufacture of magnets for motors of electric vehicles. Boat engines.
Chemical industry	High capacity as a catalyst. Transforms oils into solid fats.	Manufacture of alkenes. Hydrogenate vegetable oils.

Cobalt (Co):

Application industry	Description of qualities	Uses
Aeronautical industry and others	Formation of super alloys with other metals that give them high resistance to corrosión at high temperatures.	Aircraft turbines and devices for industrial use, also for electronic devices such as batteries for electric cars, computers, mobile phones and other electronic devices, manufactures of cemented carbides and diamond tools, milling machines and heavy military weapons. For paints, enamels and varnishes. Protector in jewelry.
Technological innovation industry	Cobalt is a metal that can be magnetized.	Magnetic tapes and magnets for the manufacture of electrical appliances.
Oil industry	Catalytic capacity	Accelerate chemical reactions.
Steel industry	Resistance and anticorrosión.	Highly powerful and resistant tools for cutting metals such as Steel.
Ceramic industry	They form green and blue colored salts	Production of pigments in the production of paints and enamels to color ceramics, porcelain and glass.
Odontology	Due to its great resistance to wear and corrosión.	Surgical utensils and tools, dental appliances.
Medicine	Co_{60} Isotopes	Radiotherapy. Sterilization of certain medical devices.

Silver (Ag):

Application industry	Description of qualities	Uses
Electronics industry	It is the best electric conductor	Switches, televisión electrodes, all Kind of electronic devices, mobile

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		pones, computers, led, chips, touch screens.
Solar energy industry	Ability to receive and transport electrical energy.	Solar panels.
Nuclear power energy	Applies to control rods for nuclear fission reaction.	Production of nuclear energy.
Welding industry	It produces a great resistance in the welding and antibacterial properties.	Welding of air conditioning and wáter pipes.
Chemical industry	Catalyst such as ethylene oxide and formaldhyde.	Disinfection of áreas and embalming agents and production of molding plastics.
Jewelry	Malleability and great value.	Manufacture of jewelry and coins.
Medicine	The silver ions act as a catalyst by oxygen which kills the bacteria. Has antibiotic and non-toxic properties.	Eye drops. Water sanitation. In dentistry for silver teeth and cover cavities.
Motor industry	High capacity to withstand high melting points produced by friction..	Ball bearings in automobile engines and jet engines.

Indium (In):

Application industry	Description of qualities	Uses
Various industries	It has a low melting point and can be liquid in alloys at room temperature. It is used as an electrolytic coating against wear on parts made of antifriction alloys. Unique properties as semiconductors in certain indium compounds (InAs, InSb).	For dental prostheses and electric motors, in control rods of nuclear reactors. Manufacture of electronic components. Mirrors.

Tin (Sn):

Application industry	Description of qualities	Uses
Various industries	It is a metal that presents White and gray colors in its allotropic form. It oxidizes on the Surface, is malleable and resistant to corrosión, which reduces the fragility of the products.	Manufacture of glass, welding, soil, in alloys with metals. Reserve cans. Manufacture of pigments, toothpastes, dyes and fungicides. Alloy of tin with copper to give bronce. Lead alloy for making tube sheets for musical organs.
Textile industry	Tin chloride is used in textile dyeing and to increase the weight of silk.	Elaboration of labels.

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Ruthenium (Ru):

Application industry	Description of qualities	Uses
Electronic and chemical industry	It is used to galvanize parts and to produce catalysts. Steam has ferromagnetic properties.	Production of acetic acid and ammonia as catalysts. Application in solar cells.
Medicine	Isotope 106.	Radiotherapies in cancer patients. Effective in treatment of parasitic diseases.
Jewelry	Coats silver pieces and gives them hasdness, prevents oxidation and scratches.	Jewels.

Antimony (Sb):

Application industry	Description of qualities	Uses
Textile industry	It has a natural silver color and is much less harmful than other chemical than lead.	Manufacture of paints, textile pigments of different colors.
Glass industry	Antimony oxide that gives strength and refinement.	Production of glass.
Technology industry	Semiconductor and insulating properties.	Infrared detectors diodes and semiconductor devices.
Rubber industry	Rubber vulcanization, given its resistance to high and low temperatures.	Vehicles.
Packaging and textile manufacturing industry	It serves as a catalyst in polymerization reactions, allowing to accelerate the speed with which a polymerization reaction of polyethylene occurs.	Manufacture of PET containers. Textile production.
Military industry	Alloyed with lead produces strength and hardness.	Weaposn, batteries and ammunitions.
Medicine	Antimony in small doses can be used to treat parasitic infections.	Leishmaniasis
Electrical industry	Currently in research to créate supercapacitators and stop using lithium for battery manufacturing. The antimonene" is a two dimensional compound capable of storing more energy than Graphene and at the same time increases the stability of the charging and discharging processes of electrical energy.	Batteries

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Manganese (Mn):

Application industry	Description of qualities	Uses
Food industry	To give more resistance and durability, prevents corrosión.	Manufacture of cans.
Agriculture	Manganese sulfate makes it posible to increase the yield of crops and prevents the appearance of fungi.	Fungicides and fertilizers.
Ceramics and numismatics industry.	Gives strength firmness and durability.	Decorative and structural ceramics. Making coins more durable when alloyed with alluminum.
Medicine	Provides protection to joints and bones, preventes cell damage due to oxidative stress.	Vitamin supplement.
Electrical industry	Improves the charging capacity of batteries.	Batteries.
Other industries.	Catalytic effect. Produces violet color and protects from solar rays. Gives resistance and increases malleability.	Eliminates engine rattling if added to gasolina and increases fuel economy. Increases the strenth of Steel. Railroad tracks, prison bars and even safes.

Chrome (Cr):

Application industry	Description of qualities	Uses
Steel industry	Provides protection against corrosión and gives shine.	Stainless steel for cuttlery
Paint industry	Gives antioxidant properties.	Different colors of paints.
Laboratories	Cleaning	Laboratory material cleaning.
Chenical industry	Catalyst	Elaboration of the synthesis of ammonia.
Leather and Wood industry	Avoid putrefaction of animal skin. Protects from wáter and waterproofs.	Leather processing. Wood preservation.
Other industries	As chromium dioxide	Magnetic tapes.

19.1.3 Limitations

It is not always easy to disassemble the parts (for design reasons), in some cases the tools are more specific, the time is longer or the vehicles that come have suffered a very serious accident and the part is missing or cannot be disassembled to recover the metals because it arrives totally broken.It has taken some time to get to know how disassembly is done. The brands are not willing to provide the necessary knowledge to carry out the disassembly operations, nor to provide information about the metals that we can find in the disassembled parts.

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For disassembly level 2:

a. There is only one part (exterior mirror) that is usually exposed in case of an accident.
b. The other parts are protected and should be available for subdisassembly.
c. There were several car parts that needed to be removed in order to access the selected critical part. However, none of the parts that had to be removed were classified as critical in Deliverable 3.1.
d. The average disassembly time is 11 min. There is only one part in SEAT Leon model II with a quite high disassembly time (exterior mirrors – 50 minutes). This is a consequence of the front lift motor location. Removing exterior mirrors requires the disassembly of door panels in any model. Nevertheless, in this model the lift motor is located inside the door plastic panel instead of inside the door metal body. As a result, removing the door panel is more complicated than in the other cases.
e. Only one part (infotainment used in SEAT Leon model II and SEAT Leon model III) requires non-standard tools for the disassembly process.

For disassembly level 3:

a. Only one part (speed sensor) cannot be subdisassembled into the required recycling fractions. In the rest of the cases, different subparts can be subdisassembled. Nevertheless, the separation degree achieved for the different fractions varies according to the given car part.
b. For example, the infotainment used in SEAT Leon model II has a subcomponent (CD reader) that cannot be subdisassembled. Consequently, a mix of ferrous, non-ferrous metals and plastics is left.
c. In the case of the combi instrument used in SEAT Leon model III, the information displayed is joined with the metallic cover, and as a consequence, there are fractions of non-ferrous metals with and without Al that cannot be separated.

19.2 Exploitation strategy

19.2.1 Exploitation routes and guidelines

For the transfer of project results and to carry out their exploitation, the direct exploitation of results can be used. In this case, it would be the project partners themselves, owners of the results, who would directly carry out the subsequent development and exploitation. Through a dissemination strategy, understanding is facilitated by potential users, it links them throughout the life of the project to obtain their commitment to make it viable and to have an efficient exploitation of the results. According to the "Guide to Exploitation and Dissemination of Results" of the Botín Foundation, they must: evaluate the barriers to carrying out the project, facilitate the transfer of project results and commit to the project. Each of these points compromises others that are important to understand the best exploitation route and finally it must be understood that for the project to be properly disseminated, the three previous points must be well compromised, because only in this way it increases the possibility of reaching the target audience and making the process sustainable.

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19.3 IPR strategy

19.3.1 Background IP access and ownership

This section will provide a description of the background IP, developed by the partners before the start of the TREASURE project. This section will also include an overview of the limitation and conditions of using the backend IP for future exploitation.

Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has prior knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA's closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT.

The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and amount of rare metals, as well as information on assembly and disassembly of parts.

If this limitation is extrapolated to possible business expansions with other car brands, it can happen the same. Companies are very reluctant to share their data, so it's a touchy subject.

19.3.2 Foreground IP

ILSSA considers that intellectual property must have guiding principles for its management and both the background IP and the foreground IP are governed by them:

a. Encourage staff for the creation, dissemination and exploitation of R+D+I for educational, commercial and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database.
f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.
g. Promote the transparency of knowledge and R+D+I result to society and industry and its industrial and commercial exploitation.

In relation to the results that are of interest for their protection, dissemination and exploitation, ILSSA is responsible for:

a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

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19.4 Exploitation risk management

The risk associated with "Knowledge of vehicle components and their composition to give them value and increase recyclability and improve the circular economy" is characterized by recognizing which are the parts that can be disassembled in the car, which are the rare metals inside of these pieces, how the pieces have to be disassembled, how to recover these rare metals and how to send them back to the assembly line in the automotive industry or in another industry so that the circle of circular economy. The risk of occurrence is described very well in tasks 3.1 and 3.2 of the European TREASURE project. The difficulty of this risk is the extrapolation of what has been learned in terms of disassembly and knowledge of rare metals to the parts of other makes and models of cars other than those studied. The risk of occurrence turns out to have a low value and its potential impact is also low.

20. Exploitation plan: ER#17

Table 22. TREASURE ER #17 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
17	Methodology development for recovery of car components and application to other automotive industries	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

20.1 Exploitable innovations and ambitions

In companies dedicated to the disassembly of end-of-life vehicles, it is very common to recover parts to give them a second life by reusing them in other vehicles. In many cases, these pieces have rare metals or components that can be salvaged. But those vehicles that are too old to salvage parts are going to be destroyed along with those parts that were once given a second chance. In the TREASURE project, ILSSA has been able to disassemble some car parts and recover components that have rare metals and other precious metals, very useful in industrial production processes. In this sense, it has been possible to return to give value to a by-product that had destruction as its destination. The circular economy thus avoids sufficient production processes that may require many natural resources such as water, energy, and other raw materials for their production.

20.1.1 Technical description

During the development of the TREASURE project, three SEAT models have been selected: Seat León II, Seat León III and Seat Ibiza IV. Of these models we have selected the following parts: combi instrument, infotainment, exterior mirrors, additional brake light, speed sensor, rain sensor and air quality sensor.

Three levels of disassembly of each car part have also been determined. Level 1 refers to the disassembly from the car, level 2 refers to the disassembly of the main part to the smallest parts and level 3 refers to the disassembly of the smallest parts to the fractions to be recycled.

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		Is it very exposed in case of an accident ?	Parts to be disassembled before	Are other critical parts broken in case of extraction instead of disassembling?	Average time in real case	Average time in ideal conditions	Difficulty level	Required tools
Infotainment	Leon model II	NO	NO	NO	10 min	6 min	High	Non-standard
	Leon model III	NO	NO	NO	10 min	6 min	High	Non-standard
	Ibiza model IV	NO	NO	NO	10 min	6 min	Medium	Standard
Combi-Instrument	Leon model II	NO	YES	NO	9 min	9 min	Medium	Standard
	Leon model III	NO	YES	NO	9 min	9 min	Medium	Standard
	Ibiza model IV	NO	YES	NO	9 min	9 min	Medium	Standard
Exterior mirrors	Leon model II	YES	YES	NO	50 min	45 min	Medium	Standard
	Leon model III	YES	YES	NO	12 min	21 min	Medium	Standard
	Ibiza model IV	NE	NE	NE	NE	NE	NE	NE
Additional brake lighting	Leon model II	NO	NO	NO	5 min	6 min	Low	Standard
	Leon model III	NO	NO	NO	5 min	6 min	Low	Standard
	Ibiza model IV	NO	NO	NO	5 min	6 min	Low	Standard
Speed sensor	Leon model II	NO	YES	NO	10 min	6 min	Low	Standard
	Leon model III	NO	YES	NO	10 min	9 min	Low	Standard
	Ibiza model IV	NO	YES	NO	10 min	6 min	Low	Standard
Rain sensor	Leon model II	NE	NE	NE	NE	NE	NE	NE
	Leon model III	NO	YES	NO	---	6 min	Medium	Standard
	Ibiza model IV	NA	NA	NA	NA	NA	NA	NA
	Leon model II	NA	NA	NA	NA	NA	NA	NA

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Air quality sensor	Leon model III	NO	YES	NO	21 min	20 min	Medium	Standard
	Ibiza model IV	NA	NA	NA	NA	NA	NA	NA

NE Not equipped in the model used in the project

NA Not-available in this model

20.1.2 Properties and benefits of the innovation

In general, the disassembly of the parts is simple, the tools used are common in most cases and the time dedicated to their disassembly is between 6 and 50 minutes. The fact of being able to recover valuable and rare metals that can be reused again, avoiding having to invest time, money and processes that have to use energy, makes it a friendly process with the environment and between to be part of the circular economy. There are no known cases in which this recovery process is carried out in the automotive industry, so it is something new and puts us at the forefront of this possible exploitation. This methodology can be applied to other makes and models of cars and thus expand to more than three models, which can be done with as many cars as possible.

20.1.3 Limitations

It is not always easy to disassemble the parts (for design reasons), in some cases the tools are more specific, the time is longer or the vehicles that come have suffered a very serious accident and the part is missing or cannot be disassembled to recover the metals because it arrives completely broken. It has taken some time to get to know how disassembly is done. The brands are not willing to provide the necessary knowledge to carry out the disassembly operations, nor to provide information about the metals that we can find in the disassembled parts.

For disassembly level 2:

a. There is only one part (exterior mirror) that is usually exposed in case of an accident.
b. The other parts are protected and should be available for sub disassembly.
c. There were several car parts that needed to be removed in order to access the selected critical part. However, none of the parts that had to be removed were classified as critical in Deliverable 3.1.
d. The average disassembly time is 11 min. There is only one part in SEAT Leon model II with a quite high disassembly time (exterior mirrors – 50 minutes). This is a consequence of the front lift motor location. Removing exterior mirrors requires the disassembly of door panels in any model. Nevertheless, in this model the lift motor is located inside the door plastic panel instead of inside the door metal body. As a result, removing the door panel is more complicated than in the other cases.
e. Only one part (infotainment used in SEAT Leon model II and SEAT Leon model III) requires non-standard tools for the disassembly process.

For disassembly Level 3:

a. Only one part (speed sensor) cannot be sub disassembled into the required recycling fractions.

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b. In the rest of the cases, different subparts can be subdisassembled. Nevertheless, the separation degree achieved for the different fractions varies according to the given car part.
c. For example, the infotainment used in SEAT Leon model II has a subcomponent (CD reader) that cannot be subdisassembled. Consequently, a mix of ferrous, non-ferrous metals and plastics is left.
d. In the case of the combi instrument used in SEAT Leon model III, the information displayed is joined with the metallic cover, and as a consequence, there are fractions of non-ferrous metals with and without Al that cannot be separated.

It is necessary to investigate the market where these rare metals can go. Below is a summary of the metals found in the pieces, the industries to which the metals can be applied and what is manufactured with them. In the pieces that have been disassembled, 15 valuable and/or rare metals have been found: tantalum, gold, zinc, copper, palladium, magnesium, nickel, cobalt, silver, indium, tin, ruthenium, antimony, manganese and chromium.

Tantalum (Ta):

Application industry	Description of qualities	Uses
Electronics industry	Store more charge per gram than other metals.	Electrical capacitors and resistors.
Automotive industry	Ignition and transmission systems with high temperature.	GPS and anti-lock brake systems.
Medical equipment	Biocompatibility capacity, does not produce toxic products	Medical implants and prostheses
Satellites and space industry	Good electrical storage capacity, minimal maintenance and low cost.	Decrease heat flux in spacecraft during planetary reintegration
Oil and Gas	Machinery and tools are subjected to high temperatures and pressures.	High resistance to chemical attack.
Military and aerospace	Produce super alloys when mixed with specific metals.	Ability to withstand extreme temperatures and stresses, such as those found in commercial and military aircraft engines. Higher internal combustion temperatures and hi

Gold (Au):

Application industry	Description of qualities	Uses
Electronics industry	The most important use of metal in industry	Manufacture of: mobiles phones, calculators, watches, GPS systems, televisions,

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		tablets, and cards, automobile electronic components (brakes and ignition systems), contact, cables, switches.
Nanotecnology	For those elements that work with very small amounts of conductors and very thin in sheets, it does not produce corrosión and allows the conduction of small currents.	Nanotechnology products
Aerospace technology	Helps to prevent your elements from being damaged and improves work capacity.	Thermal insulation for weather satelllites
Dental industry	Durable, castable, and corrosión-free properties.	Dental pieces, plates and fillings.

Zinc (Zn):

Application industry	Description of qualities	Uses
Galvanization	Prevents corrosion	Galvanizing iron for the automotive industry, electrical industry and hardware, electric vehicle batteries.

Copper (Cu):

Application industry	Description of qualities	Uses
Electrical industry and telecommunications	Electricity conductor	In the formo f copper wire in the generators of power plants, domestic and industrial motors, domestic telephony and computers, houshold electrical installations, gas, household appliances.
Mechanical field	Thermal conductivity, tensile and fatigue resistance, easy molding and ease of joining by welding.	Radiators, industrial, wáter coolers, heaters, combustion engine parts and tolos, ship hulls, propellers, pipes and oil rig equipment.
Construction	Decoration element	Coating walls, interior frames, ceiling and other elements in construction.
Chemical industry	Agriculture applications.	Fungicides and desinfectants based on copper salts,

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		copper sulfates and oxychlorides.
Health	Copper provides specific amounts of trace elements to keep us healthy, it is also antimicrobial and is a a sunstance that serves to inactivate bacteria, fungi and viruese, helping to preserve youth and skin elasticity.	Application to plants, animals and humans.

Palladium (Pd):

Application industry	Description of qualities	Uses
Electronics industry	Excellent conductive properties.	Coating of connectors in electronic devices.
Automotive industry	Properties as a catalyst.. Allows to increase the speed in the cracking of oil, accelerates dehydrogenation processes.	Catalytic converter in gasolina cars and in machines with engines.
Robotics industry	They allow efficient transmisión of electricity and reduce the generation of heat and therefore the los of energy.	Electrode in ultilayer ceramic capacitors.
Dentistry and medicine	High resistance to corrosión. Due to catalytic properties of Palladium, this metal is used as a substitute for enzymes in synthetic biology, which has allowed the effectivestudy of vaious pathologies. Antimicrobial properties.	Use on small metal plates to restore damge to dental crowns and brifges. In vitro experimentation with mammalian cells. Manufactures of surgical tolos. Blood sugar test strips.
Renewable energy	Cold fusión. It is capable of absorbing a large amount of hydrogen, which allows it to be stored for later use in power generation.	Obtaining cheap atomic energy.

Magnesium (Mg):

Application industry	Description of qualities	Uses
Automotive industry	Magnesium alloys are used in the automotive industry in the manufacture of components, which give great resistance and shine.	Tires

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Construction industry	Some magnesium compounds are very effective as refractory materials in furnaces.	Steel, iron, non-ferrous metals, portland cement and glass.
Mining industry	It has important salts with reducing properties in the mining industry.	Obtaining uranium.
Phtography and Fireworks industry	Able to give off conspicuous light.	Manufacture of flash in cameras and mobile phones. Firebombs and Fireworks.

Nickel (Ni):

Application industry	Description of qualities	Uses
Automotive industry	It has a very high level of alkalinity and high reactivity, allowing it to generate enough electrical current to start the electric motors in hybrid cars to put it into operation. Alloy with copper is very anticorrosive.	Batteries and rechargeable cells, hybride batteries for hybrid cars. Manufacture of magnets for motors of electric vehicles. Boat engines.
Chemical industry	High capacity as a catalyst. Transforms oils into solid fats.	Manufacture of alkenes. Hydrogenate vegetable oils.

Cobalt (Co):

Application industry	Description of qualities	Uses
Aeronautical industry and others	Formation of super alloys with other metals that give them high resistance to corrosión at high temperatures.	Aircraft turbines and devices for industrial use, also for electronic devices such as batteries for electric cars, computers, mobile phones and other electronic devices, manufactures of cemented carbides and diamond tools, milling machines and heavy military weapons. For paints, enamels and varnishes. Protector in jewelry.
Technological innovation industry	Cobalt is a metal that can be magnetized.	Magnetic tapes and magnets for the manufacture of electrical appliances.
Oil industry	Catalytic capacity	Accelerate chemical reactions.
Steel industry	Resistance and anticorrosión.	Highly powerful and resistant tools for cutting metals such as Steel.

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Ceramic industry	They form green and blue colored salts	Production of pigments in the production of paints and enamels to color ceramics, porcelain and glass.
Odontology	Due to its great resistance to wear and corrosión.	Surgical utensils and tools, dental appliances.
Medicine	Co_{60} Isotopes	Radiotherapy. Sterilization of certain medical devices.

Silver (Ag):

Application industry	Description of qualities	Uses
Electronics industry	It is the best electric conductor	Switches, televisión electrodes, all Kind of electronic devices, mobile pones, computers, led, chips, touch screens.
Solar energy industry	Ability to receive and transport electrical energy.	Solar panels.
Nuclear power energy	Applies to control rods for nuclear fission reaction.	Production of nuclear energy.
Welding industry	It produces a great resistance in the welding and antibacterial properties.	Welding of air conditioning and water pipes.
Chemical industry	Catalyst such as ethylene oxide and formaldhyde.	Disinfection of areas and embalming agents and production of molding plastics.
Jewelry	Malleability and great value.	Manufacture of jewelry and coins.
Medicine	The silver ions act as a catalyst by oxygen which kills the bacteria. Has antibiotic and non-toxic properties.	Eye drops. Water sanitation. In dentistry for silver teeth and cover cavities.
Motor industry	High capacity to withstand high melting points produced by friction.	Ball bearings in automobile engines and jet engines.

Indium (In):

Application industry	Description of qualities	Uses
Various industries	It has a low melting point and can be liquid in alloys at room temperature. It is used as an electrolytic coating against wear on parts made of antifriction alloys. Unique properties as semiconductors in certain	For dental prostheses and electric motors, in control rods of nuclear reactors. Manufacture of electronic components. Mirrors.

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	indium compounds (InAs, InSb).	

Tin (Sn):

Application industry	Description of qualities	Uses
Various industries	It is a metal that presents White and gray colors in its allotropic form. It oxidizes on the Surface, is malleable and resistant to corrosión, which reduces the fragility of the products.	Manufacture of glass, welding, soil, in alloys with metals. Reserve cans. Manufacture of pigments, toothpastes, dyes and fungicides. Alloy of tin with copper to give bronce. Lead alloy for making tuve sheets for musical organs.
Textile industry	Tin chloride is used in textile dyeing and to increase the weight of silk.	Elaboration of labels.

Ruthenium (Ru):

Application industry	Description of qualities	Uses
Electronic and chemical industry	It is used to galvanize parts and to produce catalysts. Steam has ferromagnetic properties.	Production of acetic acid and ammonia as catalysts. Application in solar cells.
Medicine	Isotope 106.	Radiotherapies in cancer patiens. Effective in treatment of parasitic diseases.
Jewelry	Coats silver pieces and gives them hasdness, prevents oxidation and scratches.	Jewels.

Antimony (Sb):

Application industry	Description of qualities	Uses
Textile industry	It has a natural silver color and is much less harmful than other chemical than lead.	Manufacture of paints, textile pigments of different colors.
Glass industry	Antimony oxide that gives strength and refinement.	Production of glass.
Technology industry	Semiconductor and insulating properties.	Infrared detectors diodes and semiconductor devices.
Rubber industry	Rubber vulcanization, given its resistance to high and low temperatures.	Vehicles.

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Packaging and textile manufacturing industry	It serves as a catalyst in polymerization reactions, allowing to accelerate the speed with which a polymerization reaction of polyethylene occurs.	Manufacture of PET containers. Textile production.
Military industry	Alloyed with lead produces strength and hardness.	Weaposn, batteries and ammunitions.
Medicine	Antimony in small doses can be used to treat parasitic infections.	Leishmaniasis
Electrical industry	Currently in research to create supercapacitors and stop using lithium for battery manufacturing. The antimonene" is a two dimensional compound capable of storing more energy than Graphene and at the same time increases the stability of the charging and discharging processes of electrical energy.	Batteries

Manganese (Mn):

Application industry	Description of qualities	Uses
Food industry	To give more resistance and durability, prevents corrosion.	Manufacture of cans.
Agriculture	Manganese sulfate makes it possible to increase the yield of crops and prevents the appearance of fungi.	Fungicides and fertilizers.
Ceramics and numismatics industry.	Gives strength firmness and durability.	Decorative and structural ceramics. Making coins more durable when alloyed with alluminum.
Medicine	Provides protection to joints and bones, prevents cell damage due to oxidative stress.	Vitamin supplement.
Electrical industry	Improves the charging capacity of batteries.	Batteries.
Other industries.	Catalytic effect. Produces violet color and protects from solar rays. Gives resistance and increases malleability.	Eliminates engine rattling if added to gasoline and increases fuel economy. Increases the strength of Steel. Railroad tracks, prison bars and even safes.

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Chrome (Cr):

Application industry	Description of qualities	Uses
Steel industry	Provides protection against corrosion and gives shine.	Stainless steel for cutlery
Paint industry	Gives antioxidant properties.	Different colors of paints.
Laboratories	Cleaning	Laboratory material cleaning.
Chemical industry	Catalyst	Elaboration of the synthesis of ammonia.
Leather and Wood industry	Avoid putrefaction of animal skin. Protects from water and waterproofs.	Leather processing. Wood preservation.
Other industries	As chromium dioxide	Magnetic tapes.

20.2 Exploitation strategy

ILSSA is a company that has been managing waste since 1974, almost 50 years in which it has been adapting to the different laws that the regional, central and European governments have been demanding. Being a company dedicated to the world of waste, it has been advancing and evolving according to the market. Having the ability to adapt to different times is a competitive advantage that ILSSA has, it knows the market and knows how to prepare for changes. The exploitation strategy is the management of waste that can be recovered and valued, once again offering these rare metals to the automotive market and to other markets (saving energy and water in extraction processes). Its use or market in which it can be applied is in the electronics industry, in medical equipment and wind turbines, among others. These are market niches that have not yet been exploited, the recovered materials can be sold to car part producers so that they can come back to build new or other parts.

20.2.1 Exploitation routes and guidelines

The methodology for extracting rare metals from car parts can be transferred not only to the car models that have been worked on in the project. Many other brands and models can be investigated, and information can also be collected that can be translated into new ways to obtain those rare metals so valuable in the production of parts for the manufacture of new cars or other products outside the automotive industry. Exploit this methodology to apply to other car models. At present, some of the parts that are obtained from SEAT models are common in other car brands. Ideally, this same project would be done, but applied to other makes and models of cars. In this way, any car that arrives at the CAT could be treated without distinction of make or model.

The routes to follow and the lines of exploitation would be the following:

a. The recovery of the metals obtained that are used in the manufacture of many other products and not only for automobiles. They can be used for smartphones, wind turbines, hybrid cars.
b. If the automobile industry cannot stop using rare metals to make car parts, then it must propose a more sustainable model and recover the products of those damaged parts.

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c. People want more and more to buy less polluting and more environmentally friendly products.
d. It is necessary to know which are the rare metals of the parts and see what their applications are in the industry, what production processes there are in which they can intervene.
e. Train workers in disassembly methodologies, not only for the models studied in this case, but for all models and brands that arrive at the EoL treatment centers. The Spanish car park has aged and is at the end of 2022 in an average of 14 years.
f. Promote the circular economy in this way.

20.3 IPR strategy

The process of disassembling the parts remains in the knowledge of those who have carried out the project, although it is considered that it should be known to all vehicle treatment centers at the end of their useful life. In the same way that we have disassembled the parts, other companies dedicated to the treatment of vehicles at the end of their life can do it.

20.3.1 Background IP access and ownership

This section will provide a description of the background IP, developed by the partners before the start of the TREASURE project. This section will also include an overview of the limitation and conditions of using the backend IP for future exploitation. Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has previous knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA's closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT. The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and amount of rare metals, as well as information on assembly and disassembly of parts. If this limitation is extrapolated to possible business expansions with other car brands, exactly the same thing can happen. Companies are very reluctant to share their data, so it's a touchy subject.

20.3.2 Foreground IP

ILSSA considers that intellectual property should have some guiding principles for its management:

a. Encourage staff for the creation, dissemination, and exploitation of R+D+I for educational, commercial and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database.
f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.
g. Promote the transparency of knowledge and R+D+I result to society and industry and its industrial and commercial exploitation.

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In relation to the results that are of interest for their protection, dissemination, and exploitation, ILSSA is responsible for:

a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

20.4 Exploitation risk management

The risk associated with the “Methodology for disassembling car parts at the end of their life. Recovery of rare metals" is characterized by knowing how the initial disassembly is carried out, which depends on the state in which the vehicles arrive at the treatment center, in many cases they are from accidents in which disassembly tasks are complicated, since the blows do not allow the pieces to be reached, or they arrive destroyed. It is also important to analyze the pieces to find out what the components are and in what quantities they are found within the pieces, which in some cases can reach almost 10% of the weight of the piece, the recovery of said metals to return to used and improve the recyclability of the automotive industry and the circular economy in this sector. The risk of occurrence can be mitigated by knowing perfectly how the parts are disassembled by the operators of the vehicle treatment center at their end of life, the recovery of rare metals with the simplest possible tools and preparing the workers to know all this information. For this reason, after disassembling the parts of the selected models, it can be seen that the risk of occurrence is low, and its potential impact is also low.

21. Exploitation plan: ER#18

Table 23. TREASURE ER #18 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
18	Reduction of the use of rare metals, recovery of components in vehicles and research in simpler materials	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

21.1 Exploitable innovations and ambitions

The purpose of this TREASURE project is to apply the circular economy in the automotive sector. Through the project it has been possible to know which are the most valuable components that we can find in car parts, for their recovery and subsequent reuse. Put aside the linear production processes and turn them into circular ones, which are much more beneficial for the employer, customers and above all for the environment. The rarer the metal, the higher its value, since they are scarce, but necessary to continue producing new cars. These rare metals are scarce, so their value is very high. The more they are recovered, the more they will be reused, although it

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would be necessary to consider avoiding using them and researching other materials and investigating how to make vehicles more ecologically.

21.1.1 Technical description

During the development of the TREASURE project, three SEAT models have been selected: Seat León II, Seat León III and Seat Ibiza IV. Of these models we have selected the following parts: combi instrument, infotainment, exterior mirrors, additional brake light, speed sensor, rain sensor and air quality sensor. Three levels of disassembly of each car part have also been determined. Level 1 refers to the disassembly from the car, level 2 refers to the disassembly of the main part to the smallest parts and level 3 refers to the disassembly of the smallest parts to the fractions to be recycled.

21.1.2 Properties and benefits of the innovation

It will benefit the producing companies by reducing production costs, improving their image to the client, and therefore improving their sales. Customers will also benefit, being able to buy cheaper and more ecological products.

The benefit of this innovation is the recovery of the following rare metals. In the following table you can see which the metals are obtained, their qualities and their uses in the different industries:

Tantalum (Ta):

Application industry	Description of qualities	Uses
Electronics industry	Store more charge per gran tan other metals.	Electrical capacitors and resistors.
Automotive industry	Ignitiion and transmission sistemas with high temperatures.	GPS and anti-lock brake systems.
Medical equipment	Biocompatibility capacity, does not produce toxic products	Medical implants and prostheses
Satellites and space industry	Good electrical storage capacity, minimal maintenance and low cost.	Decrease heat flux in spacecraft during planetary reintegration
Oil and Gas	Machinery and tools are subjected to high temperaturas and pressures.	High resistance to chemical attack.
Military and aerospace	Produce super alloys when mixed with specific metals.	Ability to whitstand extrem temperaturas and stresses, such as those found in commercial and military aircraft engines. Higher internal combustión temperatures and hi

Gold (Au):

Application industry	Description of qualities	Uses

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Electronics industry	The most important use of metal in industry	Manufacture of: mobiles phones, calculators, watches, GPS systems, televisions, tablets, and cards, automobile electronic components (brakes and ignition systems), contact, cables, switches.
Nanotechnology	For those elements that work with very small amounts of conductors and very thin in sheets, it does not produce corrosión and allows the conduction of small currents.	Nanotechnology products
Aerospace technology	Helps to prevent your elements from being damaged and improves work capacity.	Thermal insulation for weather satellites
Dental industry	Durable, castable, and corrosión-free properties.	Dental pieces, plates and fillings.

Zinc (Zn):

Application industry	Description of qualities	Uses
Galvanization	Prevents corrosion	Galvanizing iron for the automotive industry, electrical industry and hardware, electric vehicle batteries.

Copper (Cu):

Application industry	Description of qualities	Uses
Electrical industry and telecommunications	Electricity conductor	In the form of copper wire in the generators of power plants, domestic and industrial motors, domestic telephony and computers, houshold electrical installations, gas, household appliances.
Mechanical field	Thermal conductivity, tensile and fatigue resistance, easy molding and ease of joining by welding.	Radiators, industrial, wáter coolers, heaters, combustion engine parts and tolos, ship hulls, propellers, pipes and oil rig equipment.
Construction	Decoration element	Coating walls, interior frames, ceiling and other elements in construction.
Chemical industry	Agriculture applications.	Fungicides and desinfectants based on copper salts,

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		copper sulfates and oxychlorides.
Health	Copper provides specific amounts of trace elements to keep us healthy, it is also antimicrobial and is a a substance that serves to inactivate bacteria, fungi and viruses, helping to preserve youth and skin elasticity.	Application to plants, animals and humans.

Palladium (Pd):

Application industry	Description of qualities	Uses
Electronics industry	Excellent conductive properties.	Coating of connectors in electronic devices.
Automotive industry	Properties as a catalyst.. Allows to increase the speed in the cracking of oil, accelerates dehydrogenation processes.	Catalytic converter in gasolina cars and in machines with engines.
Robotics industry	They allow efficient transmisión of electricity and reduce the generation of heat and therefore the loss of energy.	Electrode in multilayer ceramic capacitors.
Dentistry and medicine	High resistance to corrosión. Due to catalytic properties of Palladium, this metal is used as a substitute for enzymes in synthetic biology, which has allowed the effective study of various pathologies. Antimicrobial properties.	Use on small metal plates to restore damage to dental crowns and brifges. In vitro experimentation with mammalian cells. Manufactures of surgical tolos. Blood sugar test strips.
Renewable energy	Cold fusión. It is capable of absorbing a large amount of hydrogen, which allows it to be stored for later use in power generation.	Obtaining cheap atomic energy.

Magnesium (Mg):

Application industry	Description of qualities	Uses
Automotive industry	Magnesium alloys are used in the automotive industry in the manufacture of components, which give great resistance and shine.	Tires
Construction industry	Some magnesium compounds are very effective as refractory materials in furnaces.	Steel, iron, non-ferrous metals, portland cement and glass.

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Mining industry	It has important salts with reducing properties in the mining industry.	Obtaining uranium.
Photography and Fireworks industry	Able to give off conspicuous light.	Manufacture of flash in cameras and mobile phones. Firebombs and Fireworks.

Nickel (Ni):

Application industry	Description of qualities	Uses
Automotive industry	It has a very high level of alkalinity and high reactivity, allowing it to generate enough electrical current to start the electric motors in hybrid cars to put it into operation. Alloy with copper is very anticorrosive.	Batteries and rechargeable cells, hybride batteries for hybrid cars. Manufacture of magnets for motors of electric vehicles. Boat engines.
Chemical industry	High capacity as a catalyst. Transforms oils into solid fats.	Manufacture of alkenes. Hydrogenate vegetable oils.

Cobalt (Co):

Application industry	Description of qualities	Uses
Aeronautical industry and others	Formation of super alloys with other metals that give them high resistance to corrosión at high temperatures.	Aircraft turbines and devices for industrial use, also for electronic devices such as batteries for electric cars, computers, mobile phones and other electronic devices, manufactures of cemented carbides and diamond tools, milling machines and heavy military weapons. For paints, enamels and varnishes. Protector in jewelry.
Technological innovation industry	Cobalt is a metal that can be magnetized.	Magnetic tapes and magnets for the manufacture of electrical appliances.
Oil industry	Catalytic capacity	Accelerate chemical reactions.
Steel industry	Resistance and anticorrosión.	Highly powerful and resistant tools for cutting metals such as Steel.
Ceramic industry	They form green and blue colored salts	Production of pigments in the production of paints and enamels to color ceramics, porcelain and glass.
Odontology	Due to its great resistance to wear and corrosión.	Surgical utensils and tools, dental appliances.

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Medicine	Co_{60} Isotopes	Radiotherapy. Sterilization of certain medical devices.

Silver (Ag):

Application industry	Description of qualities	Uses
Electronics industry	It is the best electric conductor	Switches, televisión electrodes, all Kind of electronic devices, mobile phones, computers, led, chips, touch screens.
Solar energy industry	Ability to receive and transport electrical energy.	Solar panels.
Nuclear power energy	Applies to control rods for nuclear fission reaction.	Production of nuclear energy.
Welding industry	It produces a great resistance in the welding and antibacterial properties.	Welding of air conditioning and wáter pipes.
Chemical industry	Catalyst such as ethylene oxide and formaldhyde.	Disinfection of áreas and embalming agents and production of molding plastics.
Jewelry	Malleability and great value.	Manufacture of jewelry and coins.
Medicine	The silver ions act as a catalyst by oxygen which kills the bacteria. Has antibiotic and non-toxic properties.	Eye drops. Water sanitation. In dentistry for silver teeth and cover cavities.
Motor industry	High capacity to withstand high melting points produced by friction..	Ball bearings in automobile engines and jet engines.

Indium (In):

Application industry	Description of qualities	Uses
Various industries	It has a low melting point and can be liquid in alloys at room temperatura. It is used as an electrolytic coating against wear on parts made of antifriction alloys. Unique properties as semiconductors in certain indium compounds (InAs, InSb).	For dental prostheses and electric motors, in control rods of nuclear reactors. Manufacture of electronic components. Mirrors.

Tin (Sn):

Application industry	Description of qualities	Uses
Various industries	It is a metal that presents White and gray colors in its allotropic form. It oxidizes on the Surface, is malleable and	Manufacture of glass, welding, soil, in alloys with metals. Reserve cans. Manufacture of pigments,

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	resistant to corrosión, which reduces the fragility of the products.	toothpastes, dyes and fungicides. Alloy of tin with copper to give bronce. Lead alloy for making tuve sheets for musical organs.
Textile industry	Tin chloride is used in textile dyeing and to increase the weight of silk.	Elaboration of labels.

Ruthenium (Ru):

Application industry	Description of qualities	Uses
Electronic and chemical industry	It is used to galvanize parts and to produce catalysts. Steam has ferromagnetic properties.	Production of acetic acid and ammonia as catalysts. Application in solar cells.
Medicine	Isotope 106.	Radiotherapies in cancer patients. Effective in treatment of parasitic diseases.
Jewelry	Coats silver pieces and gives them hasdness, prevents oxidation and scratches.	Jewels.

Antimony (Sb):

Application industry	Description of qualities	Uses
Textile industry	It has a natural silver color and is much less harmful than other chemical than lead.	Manufacture of paints, textile pigments of different colors.
Glass industry	Antimony oxide that gives strength and refinement.	Production of glass.
Technology industry	Semiconductor and insulating properties.	Infrared detectors diodes and semiconductor devices.
Rubber industry	Rubber vulcanization, given its resistance to high and low temperatures.	Vehicles.
Packaging and textile manufacturing industry	It serves as a catalyst in polymerization reactions, allowing to accelerate the speed with which a polymerization reaction of polyethylene occurs.	Manufacture of PET containers. Textile production.
Military industry	Alloyed with lead produces strength and hardness.	Weaposn, batteries and ammunitions.
Medicine	Antimony in small doses can be used to treat parasitic infections.	Leishmaniasis
Electrical industry	Currently in research to créate supercapacitators and stop using lithium for battery manufacturing. The	Batteries

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	antimonene" is a two dimensional compound capable of storing more energy than Graphene and at the same time increases the stability of the charging and discharging processes of electrical energy.	

Manganese (Mn):

Application industry	Description of qualities	Uses
Food industry	To give more resistance and durability, prevents corrosión.	Manufacture of cans.
Agriculture	Manganese sulfate makes it possible to increase the yield of crops and prevents the appearance of fungi.	Fungicides and fertilizers.
Ceramics and numismatics industry.	Gives strength firmness and durability.	Decorative and structural ceramics. Making coins more durable when alloyed with alluminum.
Medicine	Provides protection to joints and bones, prevents cell damage due to oxidative stress.	Vitamin supplement.
Electrical industry	Improves the charging capacity of batteries.	Batteries.
Other industries.	Catalytic effect. Produces violet color and protects from solar rays. Gives resistance and increases malleability.	Eliminates engine rattling if added to gasolina and increases fuel economy. Increases the strenth of Steel. Railroad tracks, prison bars and even safes.

Chrome (Cr):

Application industry	Description of qualities	Uses
Steel industry	Provides protection against corrosión and gives shine.	Stainless steel for cuttlery
Paint industry	Gives antioxidant properties.	Different colors of paints.
Laboratories	Cleaning	Laboratory material cleaning.
Chenical industry	Catalyst	Elaboration of the synthesis of ammonia.
Leather and Wood industry	Avoid putrefaction of animal skin. Protects from wáter and waterproofs.	Leather processing. Wood preservation.
Other industries	As chromium dioxide	Magnetic tapes.

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21.1.3 Limitations

Sometimes the recovery of the metals is complicated because the vehicles that arrive at the recovery center are from serious accidents, so often the parts to be recovered are missing or completely broken or have parts missing.

21.2 Exploitation strategy

21.2.1 Exploitation routes and guidelines

For the transfer of project results and to carry out their exploitation, the direct exploitation of results can be used. In this case, it would be the project partners themselves, owners of the results, who would directly carry out the subsequent development and exploitation. Through a dissemination strategy, understanding is facilitated by potential users, it links them throughout the life of the project to obtain their commitment to make it viable and to have an efficient exploitation of the results. According to the "Guide to Exploitation and Dissemination of Results" of the Botín Foundation, they must: evaluate the barriers to carrying out the project, facilitate the transfer of project results and commit to the project. Each of these points compromises others that are important to understand the best exploitation route and finally it must be understood that in order for the project to be properly disseminated, the three previous points must be well compromised, because only in this way it increases the possibility of reaching the target audience and making the process sustainable.

21.3 IPR strategy

21.3.1 Background IP access and ownership

Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has previous knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA's closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT. The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and amount of rare metals, as well as information on assembly and disassembly of parts. If this limitation is extrapolated to possible business expansions with other car brands, the same thing can happen. Companies are very reluctant to share their data, so it is a touchy subject.

21.3.2 Foreground IP

ILSSA considers that intellectual property must have guiding principles for its management and both the background IP and the foreground IP are governed by them:

a. Encourage staff for the creation, dissemination, and exploitation of R+D+I for educational, commercial and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database.

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f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.
g. Promote the transparency of knowledge and R+D+I result to society and industry and its industrial and commercial exploitation.

In relation to the results that are of interest for their protection, dissemination, and exploitation, ILSSA is responsible for:

a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

21.4 Exploitation risk management

The risk associated with the "Reduction in the use of rare metals, recovery of components in vehicles and research in simpler materials" is characterized by the difficulty of separating and obtaining rare and precious metals in pure fractions. This is defined by the treatment needs of the components and parts that contain them, the correct characterization of the composition of their materials, the correct identification of the materials to be separated and recovered and the application of recycling techniques for their correct treatment and subsequent return to the circular economy. The risk associated with the exploitation of the project is linked to the impossibility of recovering pure fractions of rare and precious metals due to the difficulty of being able to carry out the treatment and recycling process of the materials. Any failure in the process can influence this, from the correct identification of the metals to the contamination of fractions due to contamination with other types of materials or human or technical failures in the recycling process that prevent the obtaining of pure materials. The protocolized treatment processes, the correct definition of tasks and responsibilities in the treatment process contribute to mitigating the exploitation risk of the project associated with the reduction in the use of rare metals. Another aspect that will contribute to mitigating this risk is the development of project actions aimed at replacing these critical materials, through eco-design of components and parts, which replace these rare and precious metals with raw materials that have physicochemical behaviors or properties. Similar. By virtue of this, we can characterize the probability of risk occurrence as medium-low. The impact of this risk on the exploitation of the project is low since the project's actions through its dissemination and transmission of knowledge precisely contribute to protocolizing the recycling processes of these rare and precious metals, also defining measures that can be adopted for the design of automotive parts to reduce and/or eliminate the use of these materials in vehicles.

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22. Exploitation plan: ER#19

Table 24. TREASURE ER#19 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
19	Improvement in the eco-design of car parts to facilitate disassembly and improve recyclability	ILSSA	UNIZAR, SEAT	dismantlers, industrial professionals, recycling consultancy companies

22.1 Exploitable innovations and ambitions

One of the existing problems in the industry in general comes when it comes to its design. Products are designed to be used for a while and then discarded due to planned obsolescence. But in recent years, this concept is trying to be left behind because it turns out to be environmentally unsustainable. There are more and more people, we need more resources to make products, but nature has a limit and cannot withstand the pressure that human beings exert on it.

The European Union has worked to develop legislation in which the circular economy is gradually more integrated. An economy developed in order to be sustainable, recover the raw materials with which things have been manufactured and reuse them again in production processes. In this way the pressure on nature decreases.

For this reason, in-depth research into eco-design in the automobile industry is necessary, which later allows the parts and materials to be recovered, making it easy to disassemble the parts.

22.1.1 Technical description

Car manufacturers need to be aware of sharing data with automotive industries related to their end of life so that they can:

a. Know which are the components of the pieces.
b. Know how they have been assembled.
c. Know how they have been disassembled.
d. Know how to recover the valuable and rare metals that are in the pieces.

This section will include the technical description of the innovation or services.

22.1.2 Properties and benefits of the innovation

The benefits of the correct implementation of an ecological design when producing cars, can help a lot when it comes to facilitating the recovery and recycling, the disassembly of the parts and the recovery of the valuable materials that are in them. Therefore, a proper ecodesign can improve the circular economy, not only for the environment, but also improve times and processes, which are also very important.

The benefits of eco-design provide the following:

a. Use of less material, optimizing the amounts of energy and material and reducing production costs.

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b. The amount of material used per product is minimized, raw material costs are reduced and the consumption of energy resources is reduced and there is also the possibility of using renewable materials.
c. Facilitate recycling.
d. Greater durability and better quality.
e. Reduction of emissions into the atmosphere.
f. Research in innovation.
g. Use of more environmentally friendly materials.
h. Complete knowledge of the product life cycle.
i. Increases the competitiveness of the company.

22.1.3 Limitations

At present there is great competition in the industrial world and in the automotive world. The limitations that we have had when it comes to disassembling the parts have had a lot to do with the fact that the brands do not want to give information because they consider it confidential, about how the parts are disassembled and what tools must be used, even being one of the members of the consortium on this project.

The most important limitations regarding eco-design are:

a. One of the main problems limiting eco-design is research into new, more environmentally friendly materials. A significant budget is directed to research into innovation.
b. The eco-formation of society is quite a challenge to consider, although little by little there is more awareness of having a more sustainable world.

22.2 Exploitation strategy

22.2.1 Exploitation routes and guidelines

The exploitation routes and the execution schedule during the project. It has been observed that the cars that have been disassembled are from a time when eco-design is not something that has been thought of when manufacturing them. The concept of eco-design is something relatively new and not present at the time when disassembled vehicles were produced.

However, this allows us to see what is the route of exploitation that can be carried out in this regard.

a. Observe how the pieces have been made and improve their eco-design.
b. Know that the car models in which the parts have been disassembled do not have an ecological design and that therefore it must be improved.
c. Know the amount of rare metals found in them and try to reduce them in the manufacture of the following designs.
d. Recovery of rare metals to include them in the new vehicle eco-design processes.
e. Disseminate the work carried out by the TREASURE project so that it is a reference to other possible car manufacturers, companies dedicated to the disassembly of cars at the end of their useful life.
f. Disseminate the innovation carried out by ILSSA in the disassembly of car parts for the recovery of rare metals.

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g. Disseminate information about ILSSA's collaboration with car brands to improve the eco-design of car parts.

22.3 IPR strategy

22.3.1 Background IP access and ownership

Background ownership is a form of company asset, it is the prior knowledge that the company has about the product. ILSSA has extensive experience in waste management, so it has prior knowledge about the treatment of vehicles at the end of its life and can know how to act. ILSSA's closest collaboration on the TREASURE project at the outset has been with UNIZAR and SEAT.

The most important limitations with intellectual property have been mainly with SEAT when requesting information on the composition of the parts and number of rare metals, as well as information on assembly and disassembly of parts.

If this limitation is extrapolated to possible business expansions with other car brands, the same thing can happen. Companies are very reluctant to share their data, so it's a touchy subject.

22.3.2 Foreground IP

ILSSA considers that intellectual property should have some guiding principles for its management:

a. Encourage staff for the creation, dissemination, and exploitation of R+D+I for educational, commercial and industrial purposes.
b. Collaborate with third parties to generate and disseminate knowledge and intellectual works.
c. Identify the results and determine the ownership of the rights.
d. Protect intellectual and industrial property rights for registration or registration, when appropriate.
e. Maintain and publicly disseminate the records and information on intellectual and industrial property in the ILSSA database.
f. Publish and distribute when possible and as a rule by default, the results subject to content licenses.
g. Promote the transparency of knowledge and R+D+I result to society and industry and its industrial and commercial exploitation.

In relation to the results that are of interest for their protection, dissemination, and exploitation, ILSSA is responsible for:

a. Proceed, if applicable, to register them in the corresponding registry and keep it duly updated.
b. Manage its exploitation or transfer with criteria of maximum profitability and rigor in its use and respecting the principles of this regulation.
c. Disseminate and advertise appropriately in the most suitable areas that do not undermine its nature, in accordance with the principle of open access.
d. Acknowledge the authorship of the personnel who created the result.

22.4 Exploitation risk management

The risk associated with the "Improvements in the eco-design of car parts to facilitate their disassembly and facilitate recyclability" is characterized by the difficulty of finding the recovery

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of the parts and their components in the disassembly of the vehicles, due to the current design. This is defined by the need to recover the rare and precious metals that compose them and that are so scarce on these days, the correct disassembly for those vehicles that have suffered accidents, the application of more efficient techniques for the recovery of materials and their subsequent return to the circular economy system.The risk associated with the exploitation of the project is linked to the difficulty in disassembling the parts and recovering the metals, as well as the treatment and recycling of the materials. This is influenced by the fact that different car brands design their own parts, so there are as many types of part design as there are car models and this produces many ways of disassembling, different tools needed to disassemble the parts and having specialized disassembly workers. of different vehicle models. The mitigation of this risk is achieved through research actions in the design of parts that are easier in the disassembly process and that the tools used are more common. By virtue of this, the probability of risk occurrence is medium-low. The potential exploitation impact associated with this risk is low since the project actions through its disassembly turn out to be simple in terms of time spent and tools used.

23. Exploitation plan: ER#20

Table 25. TREASURE ER#20 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
20	Strategic Standardization Roadmap	UNI	yes, all interested partners can contribute to the realization of the roadmap. They may be involved depending on their technical expertise.	standardization committees (especially at CEN level); research (and scientific publications); Integrating new knowledge in Education, Trainings, etc.; all those who will want investigate/deepen the eventual gaps identified

23.1 Exploitable innovations and ambitions

The Strategic Standardization Roadmap is a document containing a series of indications addressed to the Technical Bodies, dealing with topics in line with the TREASURE project. This is in order to point out possible gaps within existing standards or the need of the market to promote the start-up of new standards, leveraging from TREASURE project research outcomes.

23.2 Exploitation strategy

The full exploitation strategy is not yet defined. However, it may include use for further research as well as use for future standardization activities.

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No commercial exploitation is foreseen for this ER.

23.3 IPR strategy

The strategic Standardization roadmap will be a public document freely available for everybody and no confidential information (e.g., protected by IPR) will be disclosed.

24. Exploitation plan: ER#21

Table 26. TREASURE ER#21 details

No.	ER title	Lead partner	Link with other partners (internal and external)	End Users
21	CEN Workshop Agreement (CWA)	UNI	All interested partners can contribute to the realization of the CWA. They may be involved depending on their technical expertise.	standardization committees (especially at CEN level); research (and scientific publications); Integrating new knowledge in Education, Trainings, etc.; all those who will want investigate/deepen the eventual gaps identified

24.1 Exploitable innovations and ambitions

The CEN Workshop Agreement (CWA)[8] is a technical pre-standardization document, developed inside an established CEN Workshop, which reflects the agreement of registered workshop participants responsible for its content. It is designed to intercept and codify an innovation (process, product, etc.) and make it available to the market so that it can be tested and then become a state of the art, hence a standard.

24.1.1 Technical description

The CWA is a useful tool for disseminating project content beyond the project duration, for the market and for all those who wish to emulate the standardize methodology elaborated in the project. The CWA will be reported to all member states of the CEN (European Committee for Standardization) to evaluate its application within their national context. The CWA is the first step towards a pure European standard (EN). For this reason, the contents described in it and resulting from the research carried out in TREASURE can be translated (if conditions will allow it) into a pure European standard (EN).

24.1.2 Properties and benefits of the innovation

CEN Workshop Agreements (CWAs) are experimental technical documents developed rapidly with discussion and input from all interested parties, with the same transparency and consensus mechanisms as in voluntary standardization. They are therefore particularly suitable for sharing

[8] https://boss.cen.eu/developingdeliverables/cwa/pages/

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innovative know-how and quickly transferring the results of Research and Innovation projects to the market.

24.1.3 Limitations

The first mandatory step to start a Cen Workshop Agreement (CWA) is the approval of CEN and this cannot be certain at this stage of the project. In case we can't manage to finalize the CWA within the project time frame we will transfer the standardization input to the relevant technical bodies (for example through the Strategic Standardization Roadmap, as reported in *Table 27. Treasure ER#21).*

24.2 Exploitation strategy

The full exploitation strategy is not yet defined, and CEN approval will be required to proceed. However, it may include use for further research as well as use for future standardization activities.

24.3 IPR strategy

A CEN Workshop Agreement (CWA) will be protected by CEN copyright. This CWA, since will be developed within the research and innovation project TREASURE, will be freely available on CEN website[9].

[9] https://www.cencenelec.eu/get-involved/research-and-innovation/cen-and-cenelec-activities/cwa-download-area/

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25. TREASURE Exploitation and next steps

This chapter summarizes the results of the analysis conducted for this deliverable as is described in the preceding chapters and define the next steps on the exploitations.
Based on a careful analysis of the objectives achieved up to M24 were identified 21 exploitable results from five different WPs.

SUPSI identified two ERs (**ER#4**, **ER#5**) from WP2 on the sustainability and circularity assessment and advisory methodologies. The assessment methodology developed within the project allows carrying out the Life Cycle Sustainability and Circularity Assessment (LCS&CA) in different project use cases. The Assessment methodology is composed of i) a selection of environmental, economic, social, and circular assessment methodologies from the analysis of state-of-the-art for the use cases performance evaluation, ii) a selection of LCS&LCA indicators and their respective calculation formulas according to criteria, such as quantifiability and data availability, and ii) a selection of existing assessment methodologies and standards to aggregate and integrate the three areas of sustainability and circularity to provide a holistic interpretation of the assessment results. The Advisory methodology is specifically designed to support decision-making related to disassembly, recycling, and eco-design of electronic components in the automotive industry. It is structured in a series of decisions for which the methodology provides recommendations and best practices to be implemented. These ERs are mainly addressed to students, industrial professionals, and consultancy companies.

EDGE identified one ER (**ER#11**) from WP2/4 that consists of a research tool on the public perception of recycling procedures and processes, ELVs and EC. In the ambit of the TREASURE platform, it provides information to industrial actors, policy makers, manufacturers, consultancy companies, academia, and citizens.

MARAS identified one ER (**ER#10**) from WP3 on the recyclability analysis and recycling rate calculations, and design for recycling feedback/advice. The recycling simulation models are developed and applied to assess the full circularity of the end-of-life stage of car (electronic) parts and products. This simulation-based methodology can be applied for the assessment of the recyclability of car designs, car part recycling performance, EoL system assessment to truly quantify and support CE in the Eol phase of products. End users of this ER are OEMs, recycling industries, disassemblers, NGOs, and policy makers.

ILSSA identified six ERs ( ) essentially from WP3. They are related to the application of the circular economy in the automotive sector. **ER#14** provide training on how to recover materials by exploiting ILSSA knowledge, further acquired as part of the TREASURE project, about how to disassemble the car components at different levels and how to prepare them to obtain valuable and rare metals of which they are composed. **ER#15** offers training and consultancy in circular economy that not only provide the knowledge but also the necessary skills to be trained in a subject that no many companies are expert. **ER#16** is mainly related to the knowledge of vehicle components and their composition to identify which are the most valuable components that we can find in car parts, for their recovery and subsequent reuse. Three levels of disassembly of each car part have also been determined. Level 1 refers to the disassembly from the car, level 2 refers to the disassembly of the main part to the smallest parts and level 3 refers to the disassembly of the smallest parts to the fractions to be recycled. **ER#17** is on the methodology development for recovery of car components and application to other automotive industries. The proposition value is to give a second life to car parts that are disassembled by reusing them in other vehicles. **ER#18** is on the reduction of the use of rare metals, on the recovery of components in vehicles and on the research in simpler materials. Critical car components are identified during the TREASURE project to guarantee a recovery of rare metals. **ER#19** is instead related to the improvement in the eco-design of cart parts to facilitate disassembly and improve

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recyclability. For all the ILSSA defined ERs the end-users are dismantlers, industrial professionals, and recycling consultancy companies.

TXT identified the TREASURE platform as ER being the only IT provider in the Consortium. The platform will be exploited as an information system that collects and provides intelligence on car electronics to promote circularity in the automotive sector (**ER#13**).

POLIMI identified two ERs (ER#1, ER#2) from WP5/6 on the use of COBOT to support dismantler operators during the disassembly of PCBs. Therefore, it is referred to a second level of disassembly to remove Surface Mounting Devices (SMD) from PCBs to increase the recyclability. **ER#1** exploit an algorithm, specifically created to communicate the presence of SMDs of a PCBs to a COBOT. The algorithm consists of a pipeline of several algorithms extracting the contours of all components on the board. The image is, then, binarized through various CV algorithms, leaving only the contours of components on the board (highlighted, so easing the COBOT to reach them). **ER#2** provides support to the operators during the disassembly of PCBs, a GUI was developed to speed up and simplify the interaction between the operator and the COBOT. The GUI allows the operator to teach new operations to the COBOT, check them through a simulation tool, save them and then execute them on call. The end-users are related to research and didactic purposes.

UNIVAQ identified four ERs (ER#6, ER#7, ER#8, ER#9) from WP5/6 on the recycling of base, precious and critical metals from different car parts. **ER#6** offers the technology for the treatment of PCBs of different car components through hydrometallurgical processes for the recovery of base and precious metals. Processes are developed according to an MLD approach to maximize the extraction yields and to minimize the production of wastewater. Wastewater treatment is also included in the technology to reuse the water. This innovation could be used in the following forms: process solutions with a Business Plan, research services and policy recommendations. **ER#7** is related on the selling of turn-key pilot and industrial plant for the recyclers. The TREASURE reconfigured hydrometallurgical pilot plant serves demonstration purposes. This exploitable result allowed to evaluate the scale-up of the hydrometallurgical processes to make investors understand the profit on the recycling processes. The results obtained within the project are used to present innovative recycling processes to the recyclers companies and other end-users in order that they directly can decide to purchase pilots and/or turn-key industrial plant. **ER#8** is related on the technology to recover critical and precious metals from LCDs from automotive sector, especially is on the recycling of indium and glass from ITO glass, but also other LCDs parts can be considered to make the process economically sustainable. **ER#9** is on the hydrometallurgical technology for the recycling of silver from in-mold electronics (IME). The process developed allows better management of this material at the end of its life, enhancing the raw materials contained. This aspect fits perfectly within the concept of the circular economy. For all the defined ERs the end-users are dismantlers and recycler companies.

TNO identified one ER (**ER#3**) from WP5/6 related on the design-for-recycling as methodology for printed electronics device building, including IME. The aim is also to offer teaching of eco-design approaches to IME industry as service. The end-users are tier suppliers.

WALTER identified one ER (**ER#12**) from WP6 related on the realization of IME products with more sustainable design, providing mandatory LCA to customers and governments if required by legislation. Demonstration of technology to customers and transversal application IME technology in other domains, such as consumer products.

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UNI identified two ERs (**ER#20**, **ER#21**) from WP8. The two documents are both aimed at identifying possible future standardization scenarios based on the project's results and at translating them to foster the market uptake of the innovation emerged within the Treasure project, bridging the gap between innovation and industry. The end users are standardization committees (especially at CEN level); research (and scientific publications); Integrating new knowledge in Education, Trainings and all those who will want investigate/deepen the eventual gaps identified.

In Table 27 is reported a synthetic list of all the identified exploitable results described above.

Table 27. Compact list of Exploitable Results

Exploitable results	ER title	Lead partner
ER#1	SMD identifier V1	POLIMI
ER#2	Learning GUI	POLIMI
ER#3	Design for recycling as methodology for printed electronics device building IME	TNO
ER#4	Sustainability & circularity Assessment methodology	SUPSI
ER#5	Sustainability & circularity Advisory methodology	SUPSI
ER#6	Selling process engineering + licenses of recycling processes	UNIVAQ
ER#7	Selling turn-key pilot and industrial plant for the recyclers	UNIVAQ
ER#8	LCDs recycling	UNIVAQ
ER#9	Recycling of silver from IME	UNIVAQ
ER#10	Recyclability analysis and recycling rate calculations, design for recycling feedback/advice	MARAS
ER#11	Reiterated research tool on public perception of the procedures and processes related to recycling, ELVs and CE	EDGE
ER#12	IME products with more sustainable design	WALTER
ER#13	TREASURE platform	TXT
ER#14	Advice on recyclability of vehicle components and their disassembly methodology	ILSSA
ER#15	Training and consultancy in circular economy	ILSSA
ER#16	Knowledge of vehicle components and their composition to value and increase recyclability to improve circular economy	ILSSA
ER#17	Methodology development for recovery of components from vehicles	ILSSA
ER#18	Reduction of the use of rare metals recovering components of vehicles research in simpler materials	ILSSA
ER#19	Improvements in eco-design of car parts to ease disassembly and improve recyclability	ILSSA
ER#20	Strategic standardization roadmap	UNI
ER#21	CEN Workshop Agreement (CWA)	UNI

In Figure 12 potential connections between the identified exploitable results are showed. Currently, the connections are essentially referred to the technical core and not to joint exploitation agreements. The connections shown in the figure are not only related to the ERs of each partner, but also between different partners. For instance, a strong potential connection concerns COBOT technology developed by POLIMI with the hydrometallurgical recycling processes developed by UNIVAQ. In fact, UNIVAQ for the treatment of PCBs studied two recycling routes: one for some specific SMDs and the other one for the board with the residual components. Therefore, the automatic disassembly would simplify the operators' efforts to

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collect the input materials for the recycling processes. In addition, POLIMI and UNIVAQ ERs are obviously closely related to those of ILSSA, especially ER#14, that promotes the circular economy in the automotive sectors by offering its expertise, acquired in the ambit of the Treasure project, to identify the critical car components and to guide the end-users for the first disassembly levels.

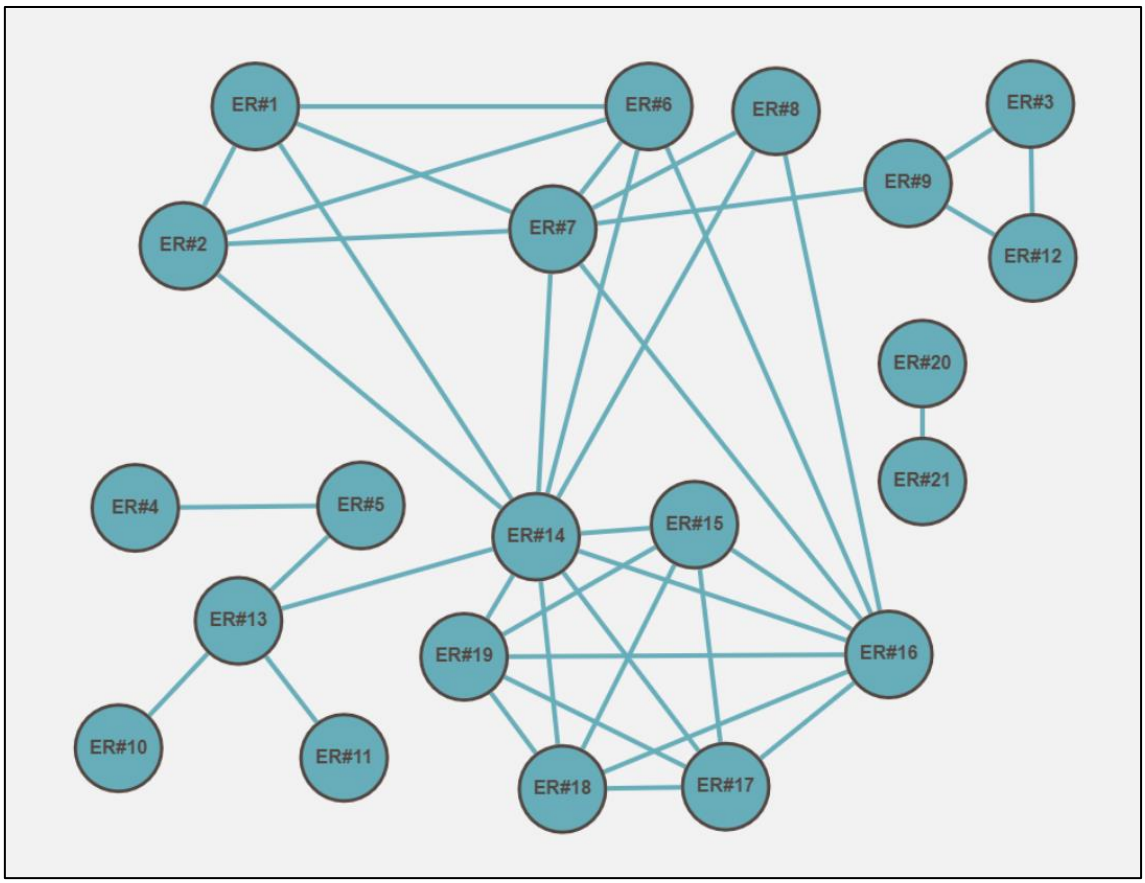

Figure 12. Exploitable results potential connections

The identified connections will allow during the next months, through dedicated sessions including all members of the Consortium, to define joint exploitations for the medium-to-long-perspective (2-5 years) and to select the main relevant results as Key ERs. To define the agreement for joint exploitations after 5 years the Treasure consortium will evaluate to open a new startup by also maximizing, for instance, the exploitation of the developed pilot plants in the market.

More in detail, the below listed exploitation models will be considered, and a decision will be taken by M30:

a. the consortium participants will set up a jointly owned spin-off company to market the platform technology;
b. one or more consortium participants will set up a revenue-shared business between themselves to offer the findings of the individual application/use case;
c. the consortium will sale/distribute exploitation rights to third parties on the basis of royalties or other ideas.

Moreover, to guide the implementation of these actions, next steps will concern the identification of Business Model and its development as separate deliverables (D8.6, D8.7). In this way a TREASURE platform's commercialization results will carry out by preparing a blueprint

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managed by UNIVAQ in cooperation with MARAS and the participants in the use cases (D8.2). Then, based on background IPR and IPR highlighted by each partner in the ambit of the individual exploitation plans, UNIVAQ will manage IPR studies with patent mapping and schemes in order that partners can exploit their results (D8.3).

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Abbreviations

AR	Augmented Reality
CE	Circular Economy
CFF	Circular Footprint Formula
COBOT	Collaborative robot
CWA	CEN Workshop Agreement
ELV	End-of-Life Vehicles
ER	Exploitable Result
GA	Grant Agreement
IME	In-mold electronic
IP	Intellectual Property
ITO	Indium Tin Oxide
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCD	Liquid Crystal Display
LCS&CA	Life Cycle Sustainability and Circularity Assessment
NPV	Net Positive Value
PCB	Printed Circuit Board
PCT	Patent Cooperation Treaty
S-LCA	Social Life Cycle Assessment

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