D7.5 - Pilot evaluation report

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Table of contents

Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776577-2.

List of figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776577-2.

List of abbreviations

Abbreviation	*Explanation*
RBAM	Robert Bosch Aftermarket Solutions GmbH
API	Application Program Interface
C-ECO	Circular Economy Solutions GmbH
CRI2-18	Common Rail Injectors 2-18
ERP	Enterprise Resource Panning
NSC	New Selection Client
STR	Striebig
VAT	Value Added Tax

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1. Executive Summary

The objective of this report is to summarize the journey of the automotive demonstrator, including the need of the ReCiPSS platform, setting-up of the ReCiPSS platform, and the benefits (technical, financial, and environmental) achieved due to the platform.

The need for the ReCiPSS platform is evident from the fact that the reverse logistics of used products or components, in the following further referred to as cores, for remanufacturing in the circular economy is overly complex since the forward and reverse logistics must be seamlessly integrated for efficient core collection. Even in a simple reverse supply chain consisting of automotive workshops, wholesaler outlets, wholesaler central, and remanufacturers repeated inspections do not provide any substantial financial or logistical benefit but increase the complexity and risk of core returns for all stakeholders involved.

The main goal for the demo phase was to physically handle and return up to 80,000 cores from the automotive workshops to the remanufacturers. This was shown by digitally incorporating the concept of the “right to return a core” and making it transferable in the independent automotive aftermarket. To demonstrate the service, two wholesalers were involved which collected more than 90,000 cores during the project period until November 2022. During the pilot, the cores were identified based on technical criteria and were evaluated and accepted/rejected based on the specific technical and commercial guidelines of the individual remanufacturers. All process stages (identification, evaluation, sorting) have been implemented as an automated workflow using the ReCiPSS automotive platform and the CoremanNet data management system.

The ReCiPSS platform compiles and provides extensive reports on core return options to understand and control the commercial opportunities and risks. This reduces the complexity for the wholesalers, as they can make an informed decision whether to accept or reject a core and where to route it.

The major challenges for the core return flow were multiple inspections and evaluations without any addition of value as well as unclear crediting conditions for the stakeholders involved such as wholesalers and remanufacturers. The identification process dealt with identifying the core as precisely as possible. The evaluation criteria not only include a technical, physical, or visual evaluation on the state of the part but also a commercial evaluation. The commercial evaluation is taken care of by specialized IT systems which enhances the decision making for the evaluation of the cores.

The intention behind processing many cores was to understand the applicability and relevance of the new concept on an industrial scale and to develop a statistically significant case that could be used to support circularity in the future. The resulting benefits span from reduced complexity of core management to improved transparency due to the implementation of procedures for commercial compensation of cores. The trust in core management is strengthened and the commercial value is better understood and estimated with enhanced visibility in the ReCiPSS platform. This in turn will pave the way for strengthening the circular economy within the remanufacturing business and improving the resource efficiency of materials in general.

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2. Automotive pilot overview

The objective of this report is to provide an overview of the automotive demonstrator pilot. It summarizes the pilot journey of the automotive demonstrator including the need for the ReCiPSS platform, setting-up of the ReCiPSS platform, and the benefits of the platform. The major objective of this report is to evaluate the technical, financial, and environmental impact of the demonstrator in terms of core returns, cost savings and environmental impact that would show improvement in efficiency, cost, and environmental impact savings. Furthermore, it highlights the opportunities that emerged both during the ReCiPSS project and beyond for the automotive demonstrator.

In the following sections, we introduce the objectives of the pilot, the automotive demonstrators overview and the pilot roll-out activities. Next to that, this document describes the benefits of the pilot from the technical, financial, and environmental impact perspectives. This document is concluded with a discussion on the opportunities identified during the pilot and outlook of the developments in the pilot.

2.1. Pilot baseline and challenges in the automotive aftermarket

In the OEM-independent automotive aftermarket, traders, such as buying groups and wholesalers, are organized based on the customer structure, behaviour, logistics, and geographical needs of the target market. The two demonstrators are wholesalers that purchase remanufactured automotive parts from 20–30 different suppliers. As wholesalers are the focus group in the demonstration, in this report the term supplier is synonymously used for remanufacturers and producers of spare parts and the term customer is used for workshops that purchase spare parts from wholesalers, unless otherwise stated. Even though wholesalers supply cores to remanufacturers, thus taking the role of suppliers of cores, this report uses the terms suppliers (remanufacturers) and customers (workshops) as in the forward-supply chain.

For forward logistics the parts are delivered from the remanufacturer to the wholesalers' central warehouse. Required parts are ordered either from the wholesalers' central warehouses or individually from the wholesalers' outlets. Afterwards, the parts are delivered to the workshops as part of several delivery tours a day. When servicing cars, workshops replace used parts, also referred to as core, with remanufactured ones. The used part is put into the original box that contained the reman part. The daily delivery tours of new and reman parts to workshops are used to also collect used parts. In the wholesaler outlets a dedicated employee analyses the parts using printed documents provided by different remanufacturers and decides whether the part is accepted or not and if the core surcharge can be credited to the workshop or not.

The forward logistics on spare parts are easily managed in a high service quality by remanufacturers and wholesalers, regardless of new or remanufactured products. But when it comes to circular part of the business for remanufacturing, the complexity is much higher.

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Before we dive into the demonstration activities for the automotive in ReCiPSS, it is useful to mention the core return challenges which led to the need for improvement in complexity, transparency, and efficiency in the core collection.

In Figure 1 an example of a reverse supply chain for remanufacturing in the independent automotive aftermarket is illustrated with its typical challenges. To incentivize the return of the used parts a common business model is to add a surcharge in the sense of a deposit between two business partners. The supply of remanufactured parts from remanufacturers to automotive workshops is executed via several trade levels, such as wholesalers and buying groups. These trade levels apply different commercial conditions and different logistic paths towards workshops, sometimes skipping layers, depending on prices and availability of reman parts. As the financial incentive (surcharge) today in most cases is only applied bilaterally between two business partners, it is difficult for all stakeholders in the reverse supply chain to determine where used parts need to be sent in order to receive credit from the surcharge on the used parts. As bilateral agreements apply, every stakeholder checks the used parts repeatedly in the reverse supply chain which is quite inefficient. Also, as the criteria on identification and acceptance of the single parts are not aligned between stakeholders, the repeated decision-making on a particular part is exposing especially the trade levels as intermediaries to financial risks. As an example: Automotive wholesalers, as one trade level, usually accept and credit most of the used parts from their automotive workshops for several reasons such as for maintaining customer relations or because they are lacking the capacity in terms of effort or know-how to check all parts, or they are not aware of the latest commercial or technical criteria from the remanufacturers or those rules are not transparent to them or it is too much effort for them to apply this in daily business. But when they are then delivering these used parts they accepted from their customers (workshops) to their suppliers (remanufacturers), wholesalers experience that financial incentives are not granted to them because the cores do not comply with the criteria of the remanufacturers. Due to the various procedures of different suppliers and the poor support available, the responsibility of checking the used parts often lies on a few employees per outlet, sometimes only one who has gained long-term experience in the evaluation but nevertheless might not be in possession of the latest documents showing the valid procedures. That overall setup bears the risk that parts are not identified or evaluated correctly, or procedures are delayed in case the key employees are not available.

The following lists plausible explanations for the lack of transparency:

- The employee at the workshops have very little access to digital support in their job.
- The documents from the remanufacturers are printouts with a risk of being outdated in terms of showing the latest criteria to be applied.
- The possibilities of identifying the core are usually limited to the information which can be found on the product box.
- Remanufacturers usually restrict the acceptable core types per reman part. This cross-reference is not accessible to the employee at the outlet.
- For the commercial acceptance check, the employee is relying on the workshops to return a copy of the original invoice of the reman part with the core which is then

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handed over to a colleague in the office who is doing the financial booking in the company's ERP system.

- Due to the high number of stakeholders involved, there is a low level of trust.

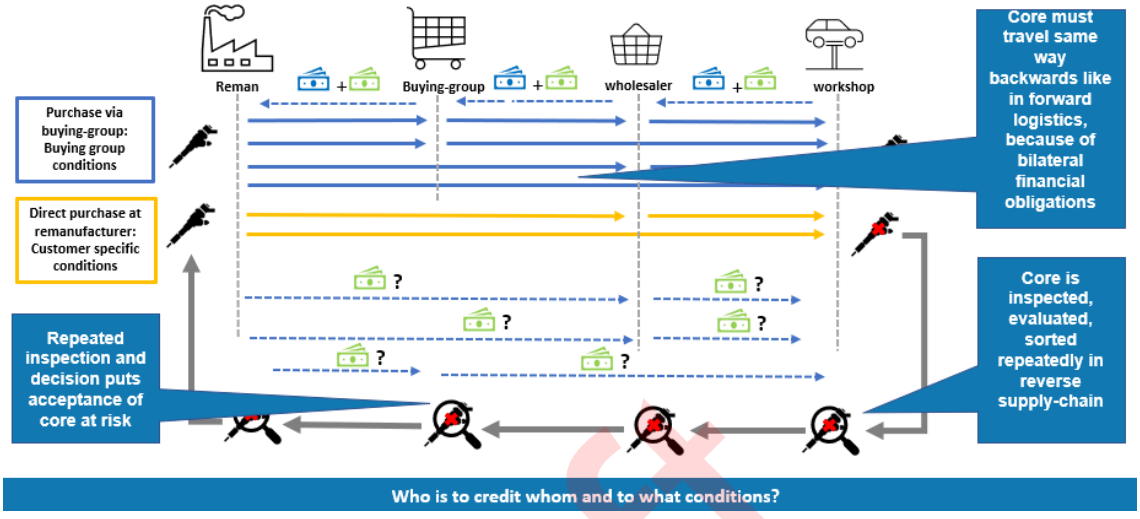

Figure 1: The core return challenges illustrated

2.2. Objectives of the pilot

The aim of the demonstrator is to show the concept of digitally incorporating the "right to return a core" and making it transferable in the independent automotive aftermarket. To address the challenges mentioned in section 2.1. for the pilot all information for the financial clearing has been bundled in a central digital platform. This platform is online and connected to the inspection infrastructure. This allows to decouple financial clearing from logistic operation, but still links the single core to the financial transactions. As shown in Figure 2, this allows an outsourcing of the physical core handling via a service using specialized infrastructure for stakeholders and at the same time gaining more control over the commercial process. To demonstrate this, two automotive wholesalers have been engaged to try out the developments of the project and the resulting service in their daily business.

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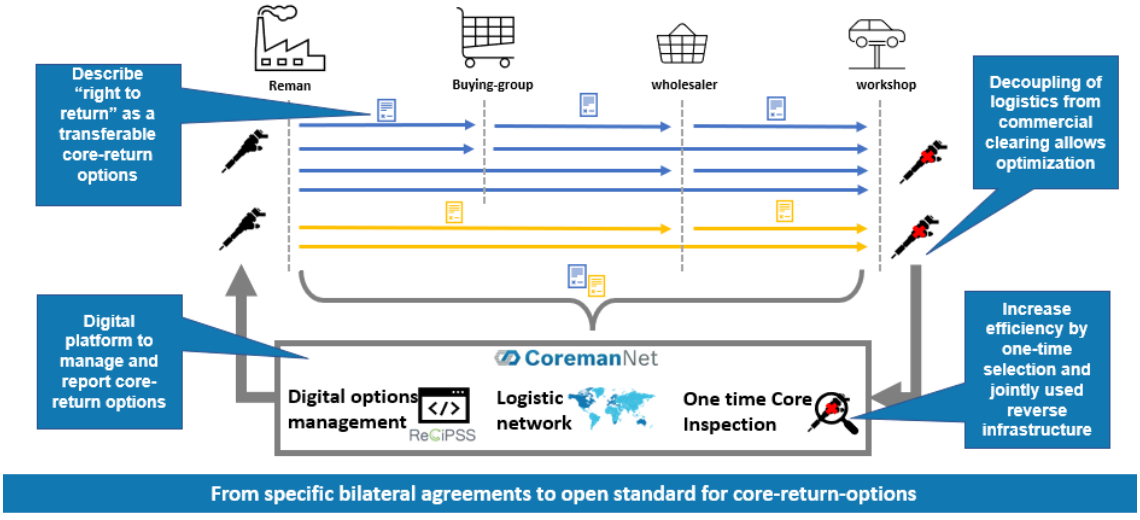

Figure 2: The ReCiPSS automotive demonstrator approach

The major obstacle to achieving benefits for core handling in the automotive aftermarket is the lack of transparency. It is not transparent to stakeholders regarding which rights to return cores are available and where and under which commercial and technical conditions. Also, these return rights are not transferable and a scalable infrastructure for managing, reporting, and executing (commercially as well as logistically) is missing. Therefore, in the demo scenario, the right to receive the financial incentive when returning a core has been incorporated in a standardized way by the concept of transferable return options. This concept has been adopted from the financial context (often referred to as "options" or "warrants") and adapted to the use for the circular economy. For demonstration and business usage, the return options have been digitally incorporated into the ReCiPSS clearing house platform (see Figure 3). This entity allows to create, transfer, exercise, expire, and report core return options in a standardized way that is adapted for automotive remanufacturing. This enables the decoupling of the financial flow from the physical flow and allows optimization of the logistics independent from physical return. Using an open interface for options management (Clearing house API, see Figure 3) which has been developed within the project, all stakeholders (wholesalers and buying groups) can connect the ReCiPSS platform to their ERP systems. The physical core return procedures of wholesalers and remanufacturers can be outsourced to a 3rd party service provider who can do the inspection and evaluation and directly provide the results to the platform. Moreover, it creates transparency in the financial flow by making the return rights transparent to all stakeholders and in this manner, all stakeholders can make the best use of their return rights, improving the allocation of cores to existing return options as well as reducing financial risks for stakeholders.

As illustrated in Figure 4, the ReCiPSS clearing house platform is connected to the existing CoremanNet infrastructure which allows CoremanNet (a C-ECO brand) to execute the options digitally and to offer physical fulfilment of core reverse logistics and core inspection as a service for platform users. In this way, the relevant data for a core will be collected only once, and redundant core inspections and decisions can be avoided.

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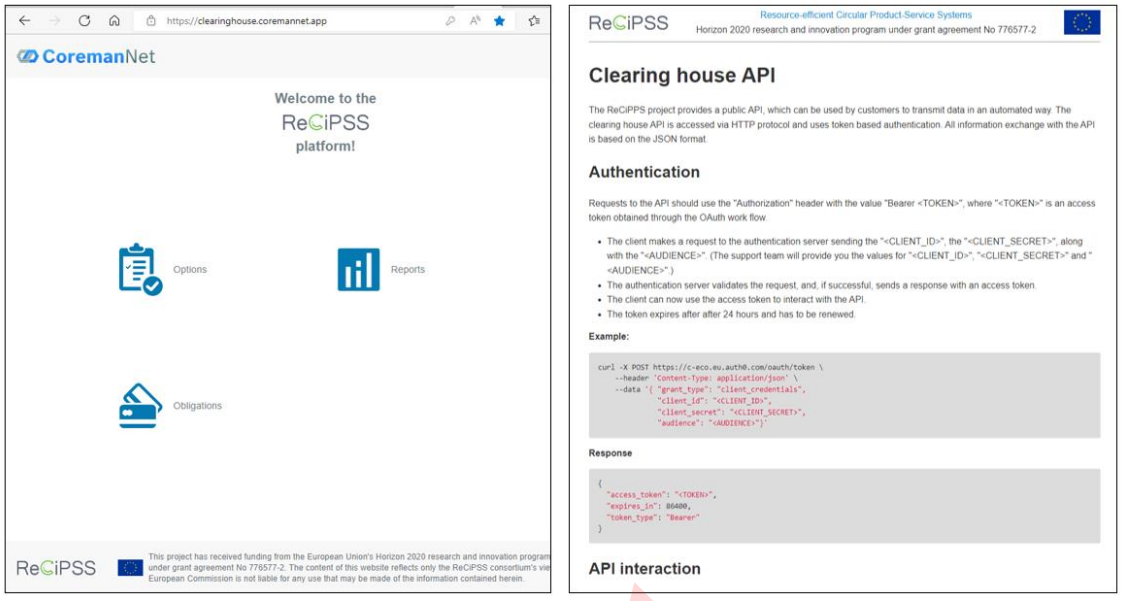

Figure 3: Screenshots from the ReCiPSS platform

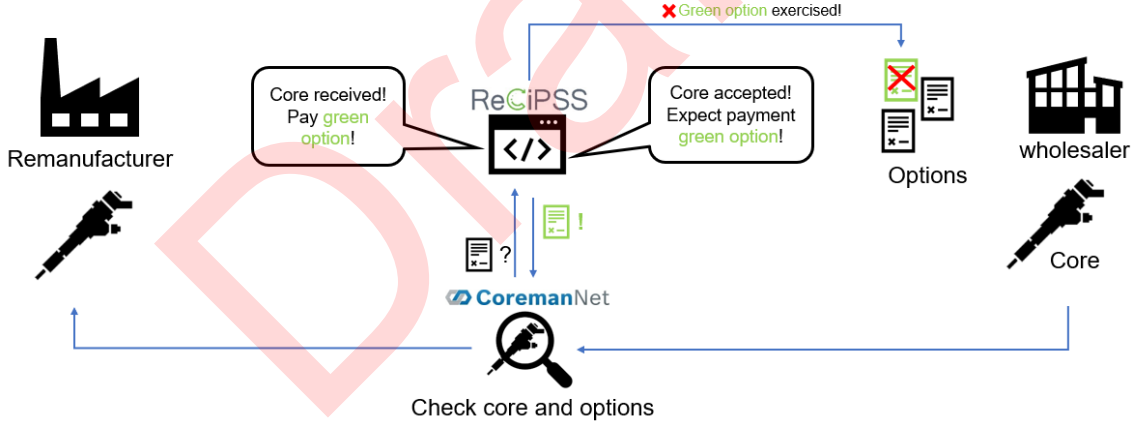

Figure 4: Exercising options

To connect digitally tracked results to the physical artifacts, cores will be marked with a unique ID. Executing the inspection process digitally and supported by up-to-date data is beneficial for all stakeholders as it eliminates the risk of applying criteria differently or using outdated versions. The cores will be collected and processed by specialists in the inspection centers and delivered to the stakeholder who has issued the exercised option and therefore pays the financial incentive.

By the central options management in the clearinghouse platform, IDs of cores can be linked to options of various stakeholders in one step to build a digital “chain-of-options”. This ensures that all stakeholders and their associated financial compensation with the core return right is determined instantly by a single inspection of the core without physical shipping. Through this,

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logistics can be optimized by identifying the destination of those cores and applying shortcuts for optimization where it makes sense.

2.3. Actors involved in the pilot

The purpose of the demonstrator was to process 80,000 cores (Bosch cores and non-Bosch cores) using the concept of core return options incorporated in the digital platform and to deploy the new process as a "Coremanagement-as-a-Service"-product for automotive wholesalers. In the following the actors involved in the pilot are described with their competences and role in the demonstrator:

2.3.1. Circular Economy Solutions GmbH (C-ECO)

C-ECO operates a worldwide network of logistic points under the "CoremanNet" brand, where the cores are delivered, inspected, and sorted for further usage. These so-called "inspection centers" are equipped with C-ECO's own developed selection system which provides a user-friendly interface for an operator inspecting the cores to gather the needed information and to decide about the acceptance in the name of the remanufacturers who are C-ECO's customers. The processes and the data are incorporated into C-ECO's IT systems. All logistic operations are sub-contracted to logistic service providers and freight forwarders. Striebig and Robert Bosch Aftermarket Solutions GmbH (RBAM) are running such inspection centers in Germany and France respectively.

C-ECO's IT system contains the technical criteria needed to evaluate the cores and background information on the acceptable cores. The criteria is provided by the remanufacturers as customers. The cores are then pre-sorted with respect to the next destination and after that forwarded to three enlarged central inspection centers in Germany, Czech Republic, and the United States. At these locations, the cores are sorted in detail as per the needs of reman production and they are stored in warehouses until they are needed in production.

2.3.2. Bosch

The Bosch Group is a leading global supplier of technology and services. It employs roughly 402,600 associates worldwide (as of December 31, 2021). The company generated sales of 78.7 billion euros in 2021. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. As a leading IoT provider, Bosch offers innovative solutions for smart homes, Industry 4.0, and connected mobility

The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiaries and regional companies in some 60 countries. Including sales and service partners, Bosch's global manufacturing, engineering, and sales network covers nearly every country in the world. With its more than 400 locations worldwide, the Bosch Group has been carbon neutral since the first quarter of 2020. The basis for the company's future growth is its innovative strength. At 128 locations across the globe, Bosch employs some 76,100 associates in research and development, of which more than 38,000 are software engineers.

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Bosch as a major remanufacturer for automotive spare parts adds this perspective to the demonstration. Additionally, Bosch was investigating how reman-specific product data could be created as part of the inspection-process and how this data could benefit the improvement of remanufacturing projects.

The former Bosch-production plant in Göttingen, Robert Bosch Aftermarket Solutions GmbH, RBAM, (now Gotion Germany Battery GmbH) was operating as an inspection center in the automotive demonstrator for the cores originating from one wholesaler in the demonstration.

2.3.3. Striebig Logistique S.A.

Striebig is operating reverse logistics in France and an inspection center within the CoremanNet-service. In the demonstration, Striebig picked up, inspected, evaluated, and sorted the cores originating from one wholesaler. Striebig Logistique provides logistics services, offering storage, warehousing, processing, and shipping of automotive spare parts. Striebig Logistique is a fully owned subsidiary of the Charles André Group, a logistics provider active in 15 European countries. Striebig Logistique has a 210,000 m² platform in Hatten (50 km northeast of Strasbourg in the East of France) dedicated to the logistics of automotive parts for customers such as Daimler, Bosch, Alstom, C-ECO and many others. Striebig Logistique operates as a logistic service provider for CoremanNet covering the physical collection, identification, technical evaluation, sorting and warehousing of the cores in France. Striebig Logistique has a qualified team in place for the physical core selection and understands very well the specific requirements of the automotive aftermarket.

2.3.4. Wholesalers as service users

Two wholesalers have been involved in the demonstration activities. Demonstrator 1 is a regional wholesaler with outlets in the southwestern part of Germany, but also has some outlets in Switzerland and Austria. In total Demonstrator 1 has 21 outlets that are supplied with reman parts either from their central warehouse in Germany or directly from the supplier in case of urgencies without having available stock. Every outlet is responsible to serve a dedicated area of workshops and the number of linked workshops could be up to some hundreds per outlet.

The core reverse flow from the workshop to the outlet is part of the daily tours when spare parts – reman or new parts – are being delivered to the workshops. Whenever a workshop has a core to be returned then the core is prepared physically with a corresponding return note that is linked with the original purchase of the reman part. The picked-up cores are then consolidated in the outlet.

Due to the high share of one supplier, the core reverse flow from the outlet for the cores arriving in packages of this remanufacturer were picked-up directly to the remanufacturer. For all other suppliers the cores were sent to the central distribution warehouse of Demonstrator 1 in mixed pallets containing cores from approximately 20-30 different suppliers. There the cores were sorted per supplier. Depending on the contractual agreement between the supplier and Demonstrator 1 the sorted cores were either shipped on Demonstrator 1 costs or being picked up by the supplier at his cost.

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Demonstrator 2 is acting throughout Europe, but for our demonstration the focus was on Germany, Austria and Switzerland. The number of outlets is 25 with additional three bigger warehouses where the procurement of spare parts is bundled for different regions (Northern Germany, Southern Germany, Austria). Most of the automotive spare parts the outlets are procuring via their respective warehouses, but in case, spare parts are not available in the warehouse or not even listed in the central warehouse assortment, the outlets might order directly from their supplier.

In the same way as for Demonstrator 1, Demonstrator 2 does not want that another player does interfere between his outlets and his customers (workshops). The core return from the workshops is professionally organised, so a regular core return flow to the outlets is guaranteed.

The core return to the suppliers was logistically fully managed by each outlet which means that every outlet needed to have correctly sorted boxes to be sent to each remanufacturer, also considering the individual logistical requirements on that level. The number of active remanufactures for the two demonstrators is approximately 20. Also, in Demonstrator 2's case, the transport needed to be organized individually in most cases, as only a handful of suppliers feel responsible for that process.

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3. Automotive pilot demonstration phase

The following section describes the steps involved in the roll-out of the service-demonstration:

3.1. Logistics set-up

The goal for the demo phase was to physically handle and return up to 80,000 cores to the remanufacturers considering the best allocation of existing return possibilities, represented by the core return options. As a learning from the co-creation workshop with the wholesalers (see D3.2) Wholesaler outlets deliver car parts (new and remanufactured) to their workshop customers in excellent logistic service up to 3-5 times a day and the cores are picked up from the outlets during the same trip. Therefore, it doesn't make sense neither economically nor ecologically to initiate dedicated pick-up transport solely for the cores. Also, the risk of losing connection to the commercial transaction or mixing up cores is small in the direct business relations and workshop compared to the further reverse supply chain. Therefore, the cores for the demonstration were picked up at the wholesalers' outlets instead of workshops. During the demonstration, the cores were then picked up from the wholesaler outlets by 3rd-party logistic providers organized by Striebig or C-ECO and delivered to the inspection centers operated by Striebig and RBAM. For the demonstration, a bundled transport of a mix of cores from the wholesaler outlets has been implemented to minimize the environmental footprint of the logistics and as well as taking advantage of the economies of scale. The mixed boxes of cores were poorly organized as they contained unsorted cores of various dimensions and weights. Some examples of the first shipments can be seen in Figure 5.

The mixed cores were shipped from the outlets to the project partners Striebig and RBAM which inspect and evaluate the cores using the system connected online to the options portfolio of the wholesaler in the ReCiPSS platform to re-sort them according to their next destination (usually the remanufacturer). In this step, cores are again bundled for transport towards the remanufacturer for better utilization of resources. During sorting, cores are also repacked and following the packing procedures of the receiving remanufacturers and creating the paperwork accompanying the boxes. An example of an outbound shipment safely packed and marked with delivery papers can be seen in Figure 6.

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Figure 5: Unsorted cores

Figure 6: Sorted cores

3.2. Inspection and sorting infrastructure

For the inspection of the cores, workstations at Striebig and RBAM have been dedicated to the demonstrator activities. The workstations are equipped with a barcode scanner, label printer, A4 printer, touchscreen, and access to the modified selection software of C-ECO with an online connection to the ReCiPSS cloud platform. A picture of such a workstation can be seen in Figure 7.

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Figure 7: ReCiPSS demonstration station at Striebig

The operators at Striebig and RBAM are unload the boxes coming from the wholesaler outlets core by core and enter the relevant information to identify and evaluate the cores into the inspection system. The system then sends a request to the ReCiPSS platform with the cores data and the platform provides the information whether a return option matching this core is available. Next, the system directly shows the operator in which sorting box the core must be put and produces a label with the unique ID of the core that is connecting the physical artefact to the inspection data of the core and the commercial options used (see Figure 8).

In this step, the system is also building the "chain-of-options" over multiple stages in the reverse-supply-chain. This allows to determine the stakeholders involved and to identify the destination of the core (usually a remanufacturer) already at an early stage of the reverse supply chain. Also, it enables the financial clearing without moving the core physically to all stakeholders involved and without repeated inspection of the same core. With the prompt availability of information in the ReCiPSS platform, the wholesalers always have exact transparency on the core-return options used and still available.

Figure 8: Core label with unique ID

3.3. Deploying the options concept in the platform

The next step after motivating wholesalers to join the demonstrator was to analyze in depth their relations towards their reman suppliers. Usually, the technical and commercial conditions for the acceptance of cores for remanufacturing are defined by the remanufactures. For the

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technical acceptance criteria, the main guideline is the question of whether a used part is still remanufacturable. Even though the criteria are similar per product group, every remanufacturer applies specific rules in detail. For commercial acceptance, the procedures are even more complex. A core-surcharge in the sense of a deposit is the dominating model, but specific parameters are defined as supplier-specific, a few examples are mentioned below:

- The time window of the validity of core return options may vary between 6, 12, 18 or 24 months.
- The return program, also referred to as cross-references, lists all material numbers which can be returned for a specific sales article i.e., a remanufactured product (1 sales article number of a reman product equals a list of possible material numbers which can be returned for this specific sales article). Theses cross-references have various levels of complexity. For example, some return programs specify the exact original equipment numbers of specific brands while others consolidate the material numbers which can be returned as part of product families.
- If the return program applies to product families, the question is how these families are compiled. This can be determined as follows:
    1. a technical classification from physical attributes of the parts, or
    2. commercial similarities, such as (a) cores that have the same surcharge, (b) balancing on total surcharge volume charged and credited in specific periods.
- The payment and crediting conditions of the core-surcharge vary, some pay-out credit notes, when returning cores, others do not apply surcharges unless certain core return quotes are met.

To incorporate these commercial parameters a concept was developed which is the foundation for the options balancing of reman suppliers, further referred to as underlying.

The quality of documentation of these rules and procedures varies between the suppliers as it was the availability of current documentation of them at the wholesalers or sometimes also at the reman suppliers. Additionally, to the commercial and technical rulesets, the suppliers usually have different procedures which wholesalers need to follow to initiate core pick-ups or how to pack the cores. The same applies to the feedback and reference to credit notes, the wholesalers receive from the reman suppliers. Here also the quality is highly different and not in favour of any kind of standard.

As both wholesalers are in business-relations to ~20 suppliers for remanufactured parts, it becomes clear that following all the different procedures and criteria is a major challenge for wholesalers operationally as well as commercially. Therefore, the processes run with rather little observation and control to limit the effort and involvement.

Overall, this unclear and complex data situation was significantly driving the complexity on acquiring, structuring, and analyzing this information. This was only possible with the support of the wholesalers initiating also direct contacts to their suppliers. The time and the effort necessary for that has been highly underestimated before the project.

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For the next step, basing on the details of the commercial model and technical criteria applied, the core return option and the underlying asset were described in data models and algorithms. The options in the ReCiPSS automotive platform are created via the API or via direct user entry in the platform UI.

The definition of the underlying asset is done by the option writer and displays their way of assigning the returnable used parts to their sold reman units. As described before, the logic could be on individual part numbers, on consolidation of different part numbers (consolidated due to financial or technical reasons), on core surcharge groups (summarizing the same product with the same core value), or even without any complex logic, meaning that all part numbers can be exercised against an open core return option. With the example of a core surcharge group, when the demonstrator transmits the purchase of a reman unit, the option will be created for the underlying of the assigned core surcharge group. The underlying of that core surcharge group contains all assigned part numbers, and for the exercising of the option it is not necessary that the same reference as in the purchase will be returned. Any of the listed part numbers will be valid equally. In Figure 9 a screenshot from the ReCiPSS platform shows an example of very specific cross-references referring to a single remanufactured product. Here an exact definition is applied of cores marked with the named OE numbers. In this case, only the original equipment (OE)-numbers from the list are accepted in return for this specific reman-product.

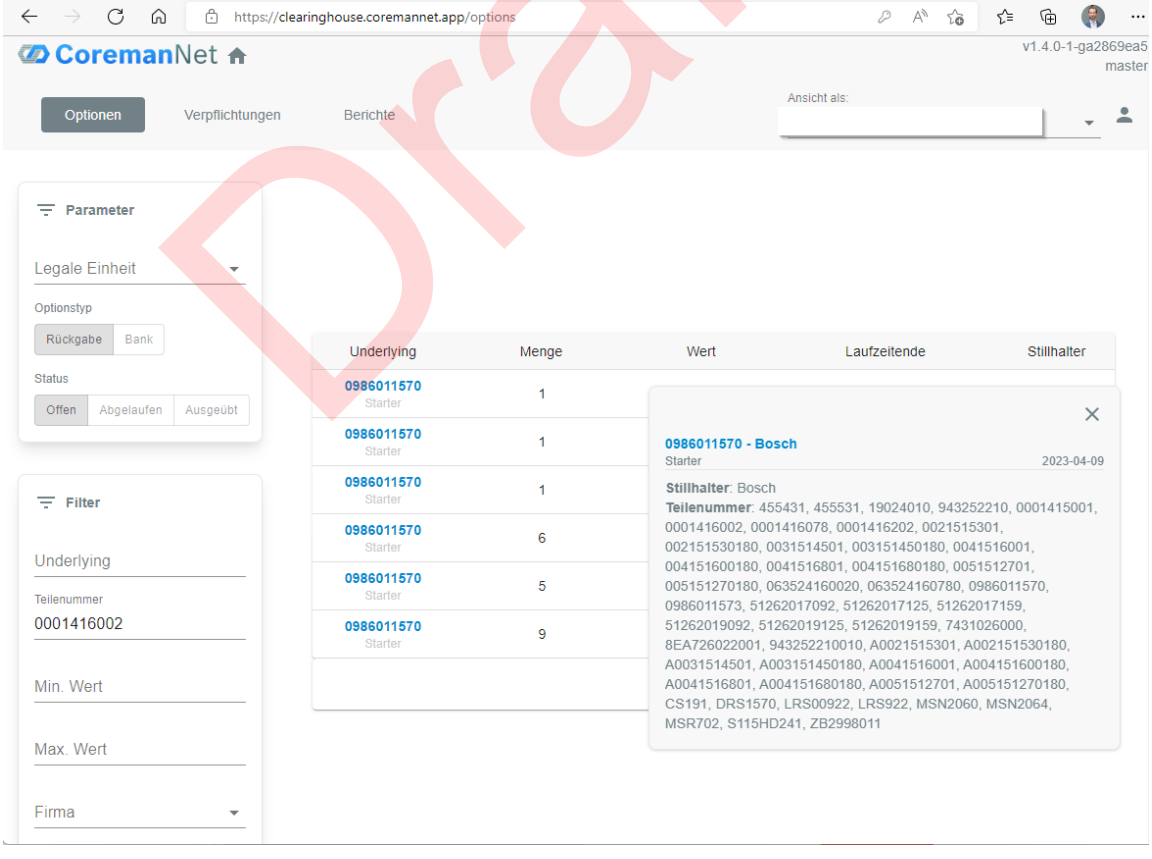

Figure 9: Part data cross-references in ReCiPSS platform

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3.4. Common Rail Injector (CRI2-18)

As discussed before, most of the activities in the reverse-supply-chain are focussed on deciding whether a core can be accepted or not and if the financial incentive should be credited. On top of that, Bosch aimed to investigate if and how the collection of information in the reverse-value chain can improve the planning of future remanufacturing projects. To do so, Bosch has collected among its experts for remanufacturing of Diesel-components requirements on data-needs on cores which would allow for improving the transparency in terms of core availability and planning the remanufacturing-activities for a generation of common rail injectors referred to as CRI2-18. The injectors of this product-generation were sold in large quantities which were expected to be returned soon after its first use-phase in cars. Nevertheless, it was not clear how that was influencing the potential for remanufacturing of CRI2-18. The data transparency of the cores was not given as there were technical changes of the product during life cycle so that it was not clear how that would influence the potential for remanufacturing as not all components of the cores would be usable. As significant number of pieces should be included in the study, Bosch decided to collect the needed data and information by inspecting products already in stock. The CRI2-18 cores carry additional information which are stored behind a QR code lasered on every single injector during the initial production of the parts. The QR code is used so that the collected data remains with injector. Since the plant has the database and the detailed selection information available, they can also use this data during the reman process. This information was assumed as potentially helpful to evaluate reman-potential. Additional qualitative characteristics should also be examined, such as the production date or level of the corrosion in the cores after storing them for some time. To collect all the missing data, a re- selection of these cores is needed. To do so, ~60,000 cores from a Bosch warehouse in Jihlava (CZ) have been transferred to RBAM in Göttingen (GER). In the selection station in Göttingen dedicated workplaces have been used for the re-inspection of the cores and to scan the QR-codes, collect the required information.

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Figure 10 CRI2-18 QR-code and dialogue

C-ECO has adapted its CoremanNet software solution (NSC) for collecting and storing information for every single core with reference to core specific ID in a database, for retrieving and decoding information out of QR code (Bosch plant number, production date), and for providing data and analysis based on request. This can be seen in Figure 10. The working places of the selection station has been adapted and equipped with all the necessary tools (scanner, new software, etc.) in order to process the re-inspection of the cores. The results have been provided to Bosch for analysis.

Main findings and conclusions of the analysis can be seen in Figure 11. The results gave clear evidence that some product-versions have much better potential for remanufacturing than others. Also, it shows the potential of collecting information related to the last usage of a product in the reverse-logistics flow and make it available for the planning of remanufacturing-production.

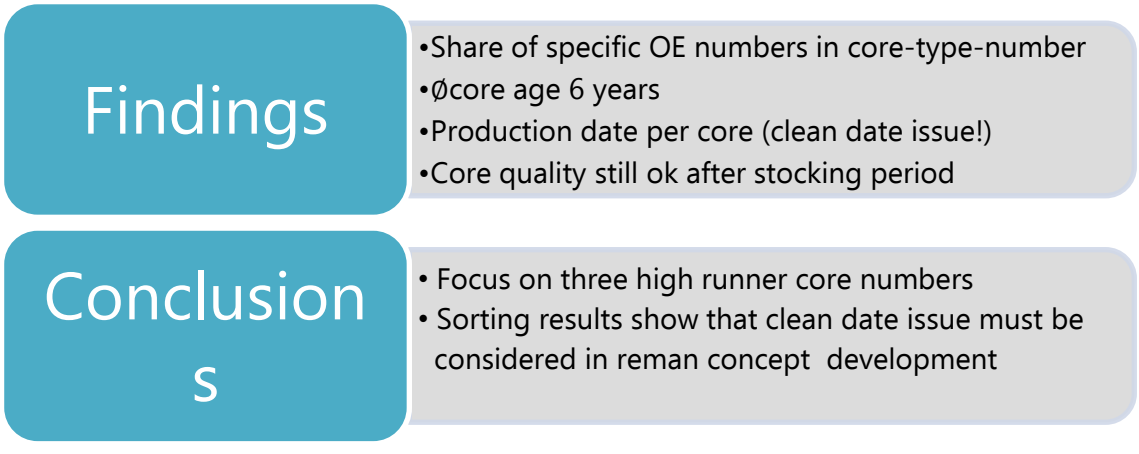

Figure 11 Results CRI2-18

4. Automotive pilot benefits

The overarching impact of the demonstrator can be observed for several stakeholders in the automotive ecosystem. The stakeholders in the automotive ecosystem are wholesalers, workshops, remanufacturers, service providers, and logistics partners. The resulting benefits span from reduced complexity of core management to improved transparency due to the implementation of procedures for commercial compensation of cores.

The goal for the demo phase was to physically handle and return up to 80,000 cores to the remanufacturers to the best allocation of existing return possibilities, represented by the core-return-options, to create a significant result. The target figures and progress for core collection during the ReCiPSS demonstrator can be seen in Figure 12.

In the following section, we describe the improvements from a technical, financial, and environmental perspective.

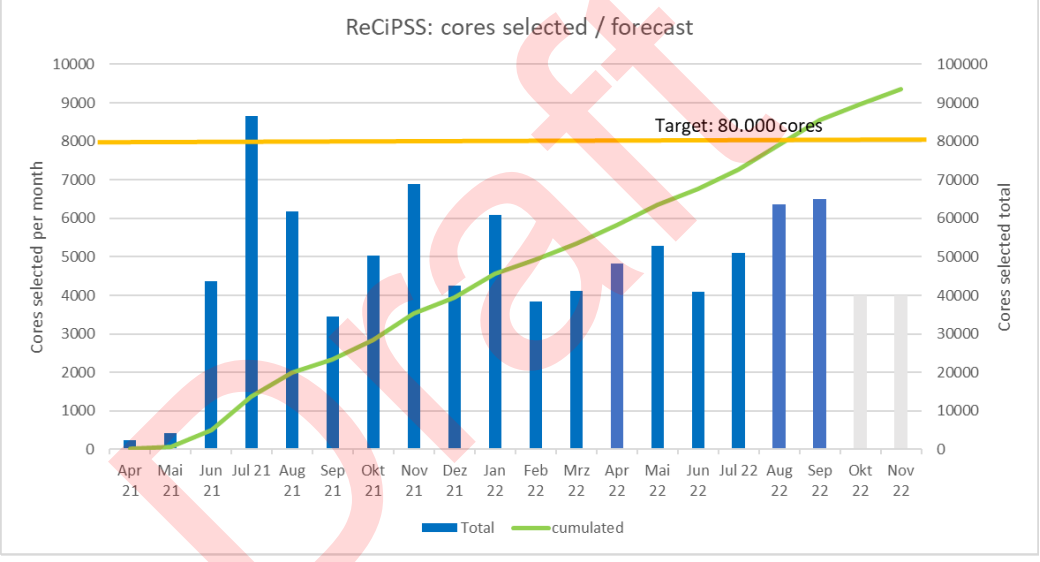

Figure 12: ReCiPSS demonstration results showing the processing 80,000 used parts reached.

4.1. Increased efficiency for remanufacturers and wholesalers and environmental impact

Remanufacturers, wholesaler centrals and wholesaler outlets benefited from an increased efficiency in their core management processes during the demonstration. These improvements led to an increased environmental impact. These benefits are discussed in the following section from the perspective of remanufacturers and wholesalers.

For remanufacturers the complexity was reduced as they only had one single pick-up location instead of several ones. Before the demonstration, when remanufacturers oversaw core pick-ups, they had to pick-up small volumes from many different pick-up locations.

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Now, there is a logistic bundling and economies of scale effect. This logistic bundling resulted in fewer shipments, fewer transport bookings, a single point of contact for support, and standardised shipment documents for the remanufacturers.

Wholesaler centrals and, particularly, wholesaler outlets were relieved from their efforts to identify, evaluate, and sort cores. Before the demonstration, wholesaler outlets had up to 25 different sorting boxes for suppliers, blocking important storage areas in their outlets. Now, they only have one sorting box, in which they collect cores for all suppliers. For contracts, in which the wholesaler oversaw the core return transports to the supplier, every single wholesaler outlet was directly delivering to different suppliers, ensuring all previously mentioned delivery requirements, such as filling in pick-up forms, printing specific accompanying transport documentation, logging into different supplier online portals to order core return pick-ups. Additionally, the frequency of pick-ups at the outlets has increased as the sorting box filled up comparatively faster and because the minimum quantity to justify pick-up was reached earlier. This also resulted in more frequent deliveries to remanufacturers.

Parallelly, this bundling of cores in the reverse logistics and the jointly used logistic infrastructure improved the economic and environmental impact due to better utilization of logistic resources. The improvement in core transports is displayed in Figure 13.

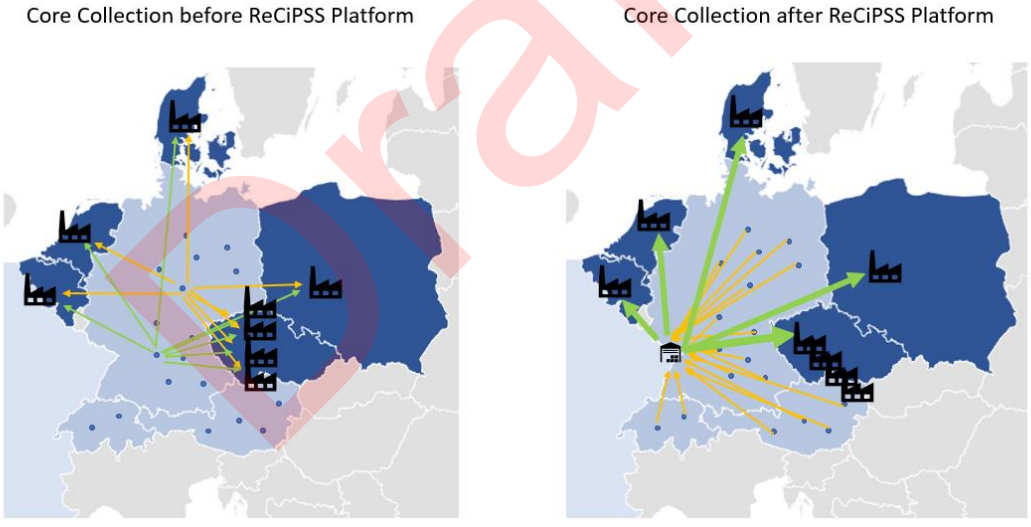

Figure 13: Improvement in the environmental impact due to reduced transport (bundling of cores)

From the perspective of the environmental impact of the demonstrator, it can be stated in general, the remanufacturing of automotive parts in comparison to the production of new parts leads to significant savings in energy, material, labour, and CO2. This can be observed in Figure 14, however the pre-condition to achieve these positive effects is the availability of cores. So, every innovation which can make remanufacturing “more mainstream” is directly benefitting to the environmental savings achieved by more remanufacturing. As described above, the service set up in the automotive demonstrator is reducing complexity and effort for service-users in reverse logistics and core management. Therefore, the concept of core-return-options, the digital platform incorporating it, the service, and the reverse logistic infrastructure are removing

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or at least easing some major obstacles for companies to do more remanufacturing. So, the innovations demonstrated here in a real business environment are an enabler to remanufacturing also for companies who were not able to tap into this field on their own.

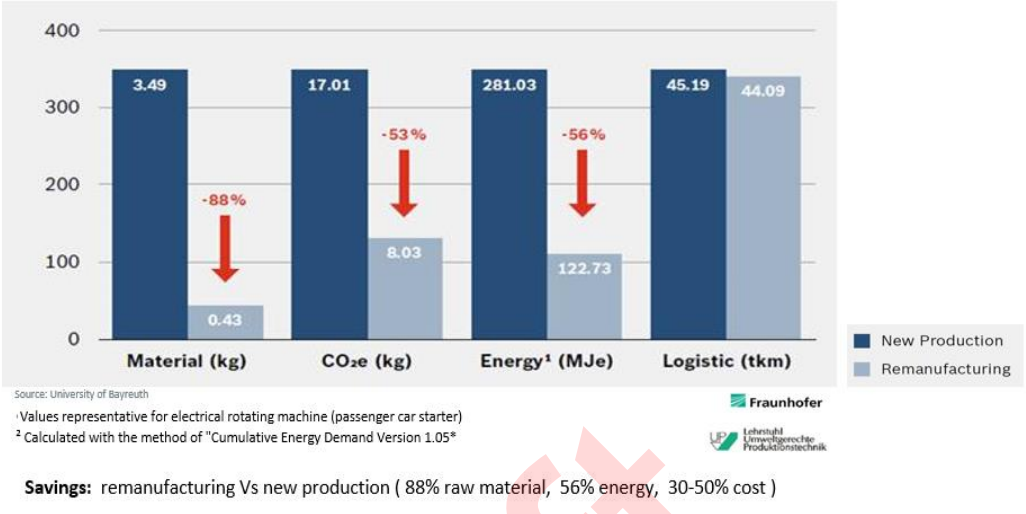

Figure 14: Environmental impact savings of remanufacturing in general

Moreover, for those products which have been inspected at the demonstrator 1 outlets upfront, RBAM either confirmed or updated the information that already entered the system. Afterwards, they allocated and bundled the cores for shipping to the relevant remanufacturers. Even though, the target is to have a one-time inspection in the reverse logistics flow, this step was conducted during the project to acquire core-specific data on deviations between the first inspection in the outlet and the second inspection at the C-ECO selection centre. The background to that is to create trust for the wholesaler in the inspection-results of a third party. Due to COVID-19 restrictions, this process could not be conducted to the full extent. However, first results show that the deviation is minor (~1-2%) compared to the extra effort of sending every core to additional locations, duplicating the inspection, and also maintaining the needed logistic structures and knowledge for that. C-ECO will continue to create data on the deviations to improve the system and convince wholesalers to trust in the inspection results.

4.2. Enhanced transparency for wholesaler towards suppliers and customers

One of the major improvements for wholesalers was their increased transparency towards their suppliers and customers. Both demonstrators have transparency over their physical and commercial core reverse flows with all suppliers. Starting with the transparency about commercial flows, the platform provides wholesalers with live balances for every supplier. Figure 15 shows an overview of all open options for all suppliers. The view can be changed to expired and exercised return options both in value and pieces.

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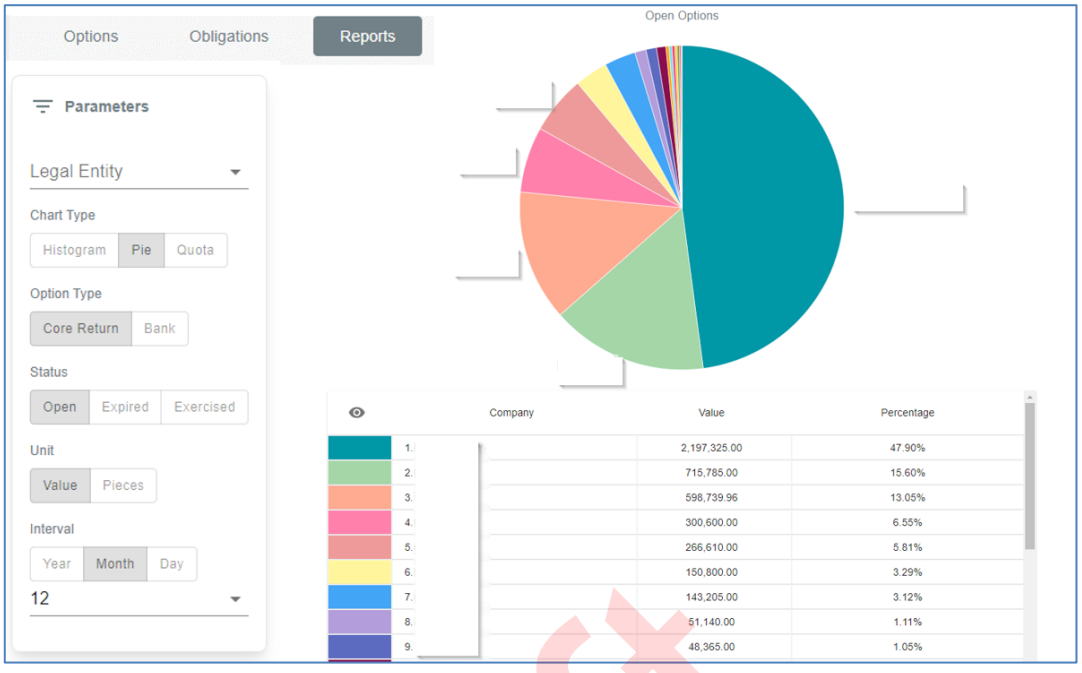

Figure 15: Live balances for every supplier

Working with the live balances, the demonstrators can analyse their core return options in more detail on a supplier level and a product level. Figure 16 shows the overview of open return options with one specific supplier over the coming 12 months. The same overview exists for expired and exercised return options. To compare the core return quotas of all suppliers, demonstrators can access the view exercised quota (Figure 17).

Figure 16: Historical allocation of all open, expired, and exercised return options of one supplier

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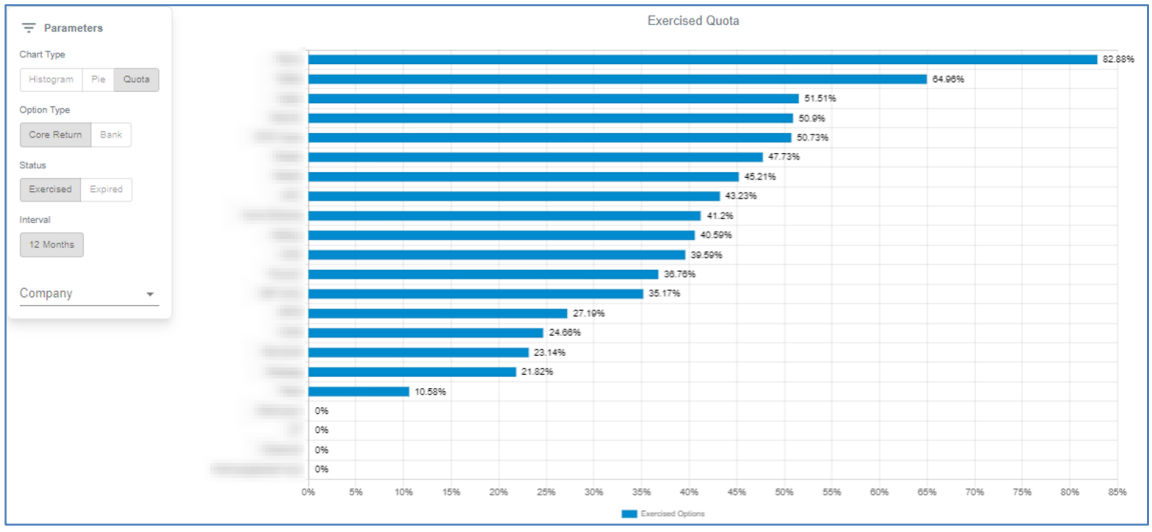

Figure 17: Exercised options per supplier over last 12 months

Furthermore, wholesalers are now able to review credit notes related to the so-called core bank which some suppliers use to handle exceeding cores. In case wholesalers return cores for which no return options are available at that time, remanufacturers park these core returns on a core bank without crediting the core-surcharge until the wholesaler buys matching remanufactured products. In this event a corresponding credit note is triggered. These payments were difficult for the receiving wholesalers to match as a core-surcharge payment could not be matched directly with a core-shipment. By introducing a special options category in the ReCiPSS platform this relation can be traced now. Figure 18 shows how much money has been paid out due to exercised options on the core bank.

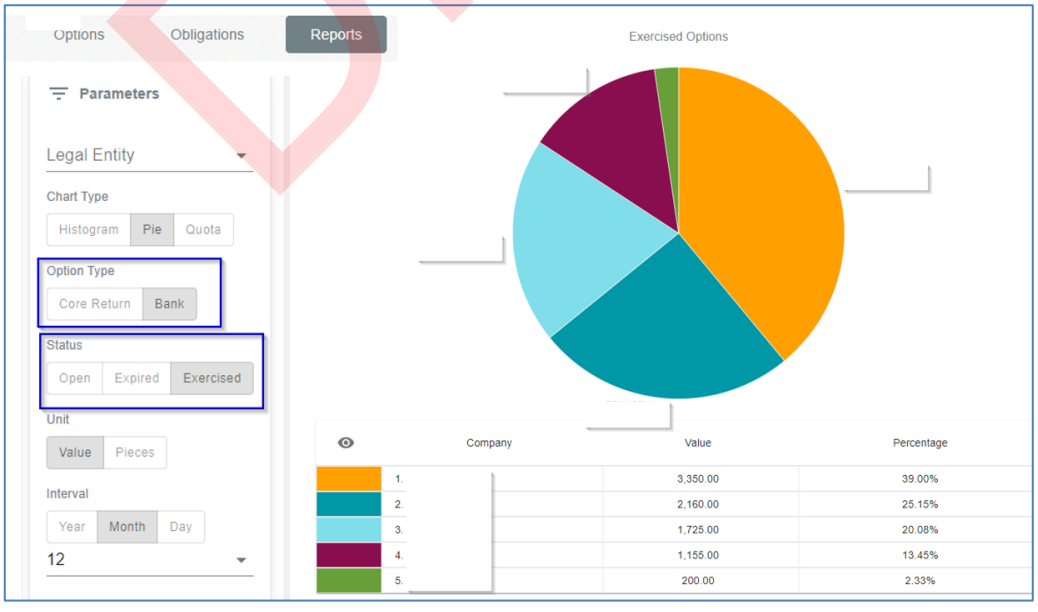

Figure 18: Basis for review of credit notes from exceeding core returns

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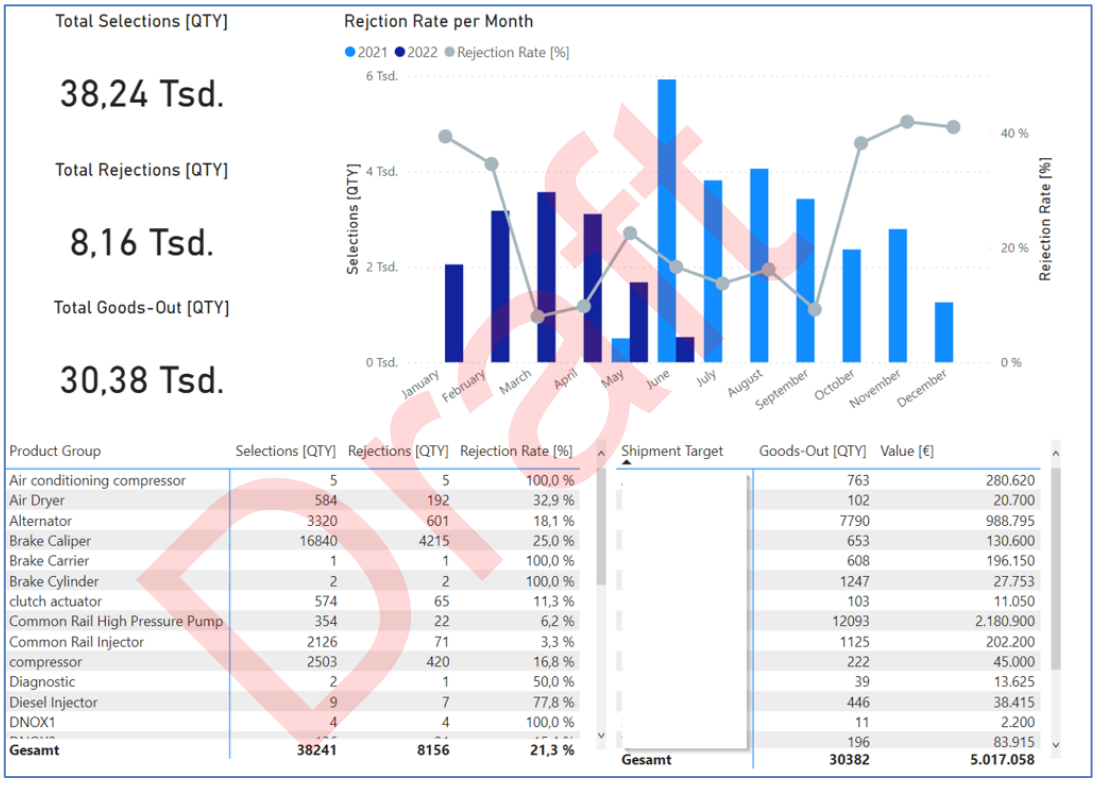
Turning to the physical reverse logistic flows, wholesalers see an overview of all selections results and deliveries to their suppliers (Figure 19) and they see analyses of the rejection reasons (Figure 20). Based on these analyses (Figure 20) they are also able to evaluate the delivery quality of cores from internal wholesaler outlets before sending them to their suppliers. A significant learning during the demonstration analyzing the rejection reasons was that the "commercial" rejection (represented by reasons "not in program" and "no option" in Figure 19) is much more relevant than the technical rejection due to damages of the used parts. While the technical rejection is usually perceived as the main reason why parts are not available for remanufacturing, it can be seen that in fact the rejection related to the commercial and logistic processes is much more relevant and usually underestimated.



Product Group	Selections [QTY]	Rejections [QTY]	Rejection Rate [%]
Air conditioning compressor	5	5	100,0 %
Air Dryer	584	192	32,9 %
Alternator	3320	601	18,1 %
Brake Caliper	16840	4215	25,0 %
Brake Carrier	1	1	100,0 %
Brake Cylinder	2	2	100,0 %
clutch actuator	574	65	11,3 %
Common Rail High Pressure Pump	354	22	6,2 %
Common Rail Injector	2126	71	3,3 %
compressor	2503	420	16,8 %
Diagnostic	2	1	50,0 %
Diesel Injector	9	7	77,8 %
DNOX1	4	4	100,0 %
Gesamt	**38241**	**8156**	**21,3 %**

Shipment Target	Goods-Out [QTY]	Value [€]
	763	280.620
	102	20.700
	7790	988.795
	653	130.600
	608	196.150
	1247	27.753
	103	11.050
	12093	2.180.900
	1125	202.200
	222	45.000
	39	13.625
	446	38.415
	11	2.200
	196	83.915
Gesamt	**30382**	**5.017.058**

Figure 19: Analysis of inspection results and deliveries to reman suppliers via filter options

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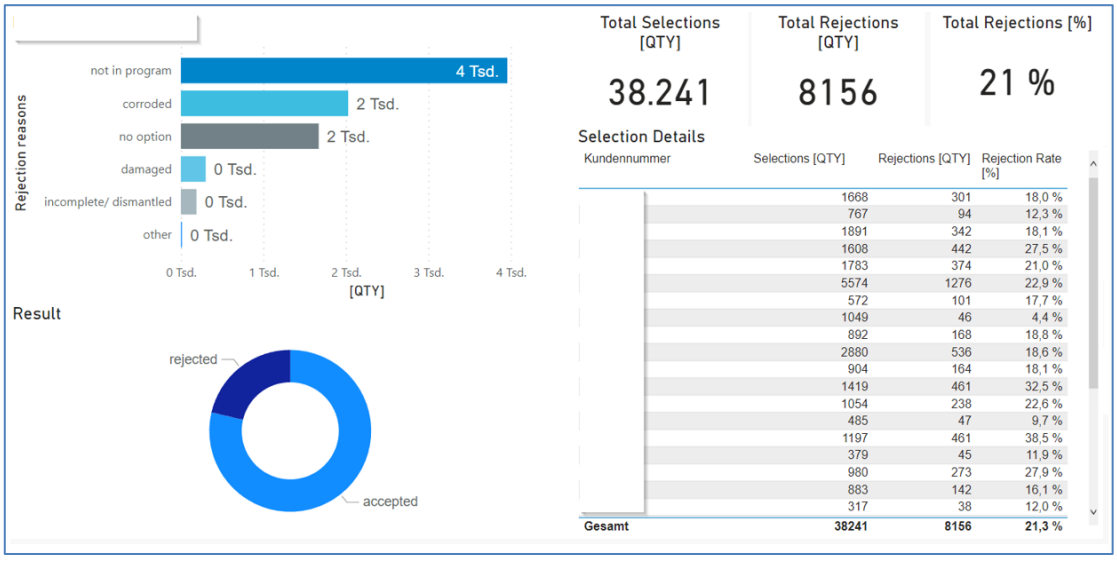

Figure 20: Analysis of rejection reasons

4.3. Improved financial performance

For wholesalers, the financial performance improved through savings and financial risk reductions towards both suppliers and customers.

Starting with the perspective towards suppliers, in several situations, wholesalers reduced the expiration of return options to approximately 150.000 Euros owing to an improved transparency of core returns on the platform. For example, as part of an analysis of how one supplier booked core returns, it turned out that this supplier did not correctly book open return options with returned cores. The supplier booked returned cores against options that were not the latest ones, as declared in his terms and conditions of core balancing, but against younger options leading to the risk of the expiry of options in the amount of 20.000 Euros.

Figure 21: Option expiry dates of one supplier

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In another example, a supplier applied a very short core return window and wondered why no cores are coming back. Furthermore, there was no financial incentive, in form of a surcharge, applied from the wholesaler to its customers. As a result, cores did not come back, and options expired for the wholesaler. Through data transparency, core flow observations and feedback dialogs with both the wholesaler and the supplier, the wholesaler applied a surcharge towards its customers and the supplier extended the core return window leading to steady core return flows for the supplier and an extended core return period for the wholesaler. If the supplier had applied their contractual penalty for not sending in cores, the financial risk for that wholesaler would have been more than 50.000 Euros a year.

Furthermore, one wholesaler achieved an improved customer categorization from their supplier which resulted in savings of about 50.000 Euros a year. Depending on the overall quality of core returns, this supplier groups their customer into different categories. If the overall core quality is very bad, the customer category is low and the application of core return criteria during the evaluation is very strict. However, if the overall core quality is good, the customer is grouped into a higher customer category in which cores are accepted which in previous categories have been rejected. In the highest customer category, all cores are accepted. The improvement of the customer category at the supplier was achieved through tracking and analysing core evaluation results from the supplier, comparing them to the self-created evaluation results within the demonstration and engaging in dialogs with the supplier to better understand core rejections. Through this feedback dialog and the following necessary adaptions in the core evaluation process, less and less cores were rejected leading to better customer categories at the supplier. Finally, the wholesaler was grouped into the best customer category in which all cores in all core return deliveries were accepted by the supplier. Before the demonstration, the wholesaler was not even aware of the procedure at his supplier of being grouped into different customer levels depending on the quality of core deliveries.

Moreover, the analysis of core evaluation results of this supplier revealed that one rejection criteria which led to rejections in the core evaluation process at the supplier, was not communicated as part of the core criteria manual to customers. All concerned core rejections were accepted and credited to the customer. However, this shows that several cores were rejected without authorization in the past.

As part of another example the wholesaler was able to reduce the risk of option expirations in the total surcharge amount of 50.000 Euros. Through the improved transparency in the ReCiPSS platform it became visible that a high surcharge volume was about to expire shortly (Figure 22). Owing to this information the wholesaler was able to contact his supplier, explain the situation and ask for a prolongation for these options. As a gesture of goodwill and in the interest of receiving the cores, the supplier extended these options for another month. This shows that only the transparency given on the ReCiPSS portal enabled the wholesaler to recognise the financial risks involved in core management and consequently act and have negotiations with the supplier.

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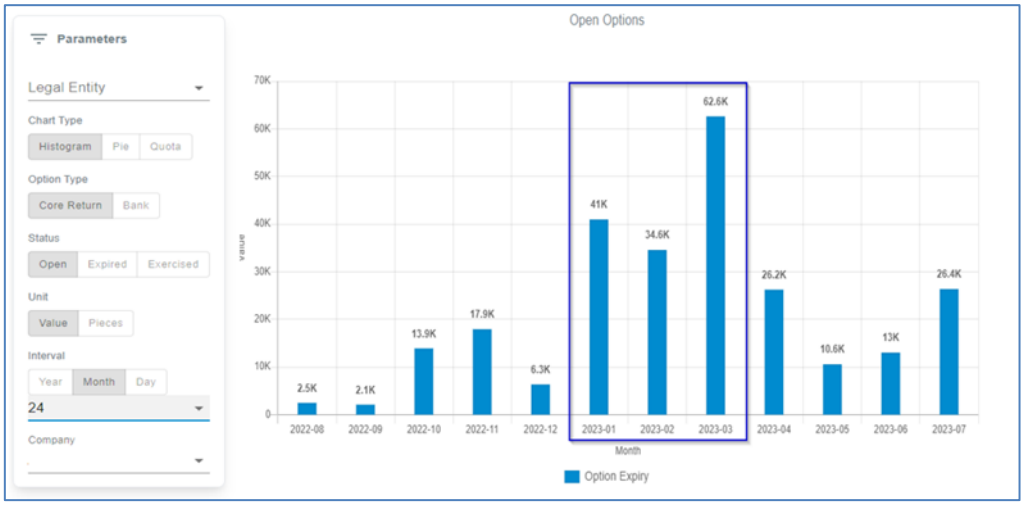

Figure 22: An example of an option expiration report in the ReCiPSS platform

Most importantly, the transparency solved a major challenge for wholesalers, which was the review of credit notes from suppliers. Previously, wholesalers had only limited possibilities, if any, to connect credit notes to relevant core returns and to review the accuracy of the credit notes. As many suppliers' credit notes did not have a reference number to goods-out of core returns, wholesalers had high efforts to understand how credit notes and goods-out are related. In some cases, suppliers also consolidate all payments to their wholesaler customers per month to limit the number of financial transfers which also increases the complexity to trace payments to transactions. In addition, in cases, where suppliers do not provide feedback on core acceptance and rejections or feedback is in a poor quality, it was even not possible for them to verify the accuracy of credit notes. Since the demonstration the wholesalers compare the data from goods-out reports of core returns with the content of their credit notes which are now connected to the goods-out reports through specific references. This transparency now enables wholesalers to review credit notes and reduce financial risks which are involved in core bookkeeping.

Turning to the perspective towards workshops, wholesalers can also review which open options their customers (workshops) have for which reman products (Figure 23). For example, taking the situation in which, a workshop purchases a reman product from wholesaler A. However, when it comes to returning the core, the workshop goes to wholesaler B (from which he didn't buy the reman product), the outlet of wholesaler B can then type in the part number in the ReCiPSS platform at his point of sale and check whether his customer has return options for this particular part. This reduces the financial risk of the wholesaler of paying-out surcharges to workshops that do not have return options.

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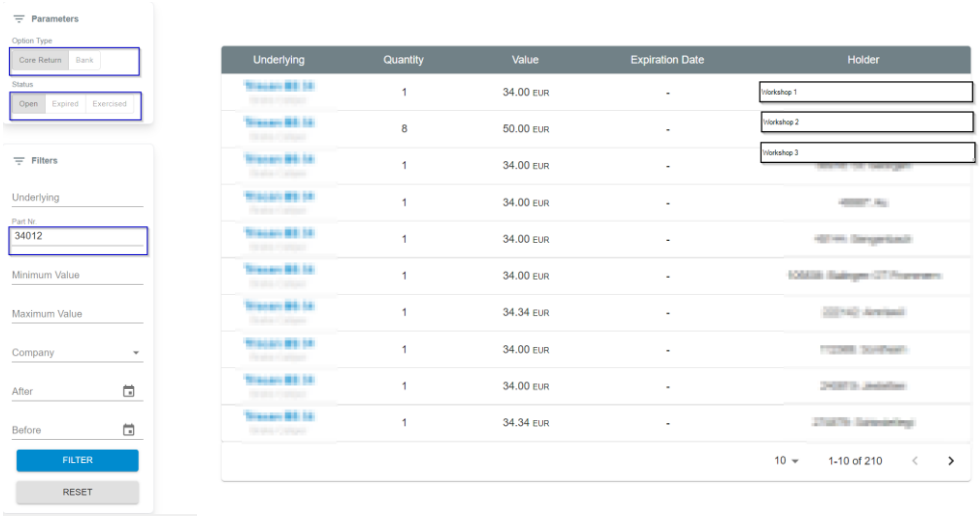

Figure 23: Open options for a selected part number of workshops linked to a wholesaler

4.4. Ecosystem building and proof-of-concept

Wholesalers have a vital role in the circular business approach as they are bridging the gap between the remanufacturers of spare parts and users of remanufactured parts. But till today they are not well integrated in the processes nor supported in their challenges. In today's automotive aftermarket, wholesalers that buy remanufactured spare parts are burdened with the most complexity as well as they face the highest risk of losing money on the cores. At the same time, they are considering themselves poorly supported by the remanufacturers and covering imperfections in the return-process on their own account for the sake of good customer relations to their workshop-customers. Even though, wholesalers have a high potential for improvements, it was very difficult to convince first wholesalers to join the demonstrator as early adopters. As by the high complexity of the whole matter, it was challenging to communicate the benefits to them, especially without any successful reference or proof-of-concept. It can now already be seen that the successful implementation of the demonstration in ReCiPSS serves as positive reference. Not only that both wholesalers intend to continue to use the service after the end of the project, C-ECO has already onboarded a 3rd wholesaler as new service-user.

Another positive outcome is that the ecosystem of supported core-returns procedures build within ReCiPSS automotive demonstration covers a wide range of suppliers now. Currently, the ecosystem consists of more than 30 suppliers. By this extensive overview, it is possible to offer "Core-Management-as-a-Service" covering a wide range of remanufacturing-suppliers and product-categories in the European automotive aftermarket. C-ECO has combined physical and digital service components for a "ready-to-use" Core Management offer to automotive wholesalers. The service is fully operational and commercially available as a product. This means that it is not necessary anymore for automotive wholesalers to burden themselves with the complexity and effort of handling used parts and at the same time, gaining transparency and control over the business via digital support. This will be beneficial for the long-term

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development of core management through digital platforms and for the remanufacturing business in general.

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5. Conclusion

The primary goal of the ReCiPSS automotive demonstrator was to create an ICT platform that would improve the remanufacturing capacity of used car parts by improving the transparency, commercial viability and minimizing the complexity inherent to reverse logistics. This was shown by the collection, identification, evaluation, and sorting of more than 80,000 cores with the involvement of wholesalers in the demonstration of the ICT platform.

Many developments have been made throughout the course of ReCiPSS, such as deploying the ICT platform, collecting cores from different wholesalers' outlets, bundling the cores, and collecting bigger batches to reduce transport distances and emissions. The data management platform has been continuously upgraded with different features and functions for operational control of core management as well as innovative features such as "chain-of-options".

By building this so called "chain-of-options" it is possible to document the ownership change of a core over several stakeholders without having to deliver the physical core between them or to repeatedly inspect the core again. This allows the optimization of logistics independent from the commercial clearing. A particularly important aspect of the service developed in ReCiPSS is the digital link of the physical cores to the commercial conditions of the core incentives represented in the digital core return options in the platform. With that feature, the ReCiPSS platform is capable to manage complex supply chains and to allow logistic optimization of the reverse flows decoupled from the commercial clearing.

The ReCiPSS ICT platform provides the technical infrastructure to create, report, exercise, transfer, and expire digital core return options. By using personalized accounts, the individual options portfolio is accessible to all market stakeholders and enables them to transfer their options to other platform users. With this structure, it is possible to decouple the financial and physical flow and to optimize the logistics independently. The extensive reporting on the commercial situation creates transparency regarding the financial obligations resulting from granting and holding of return rights for all connected stakeholders. The digital ReCiPSS automotive platform is fully operative and providing the users full transparency on the commercial situation of their used parts returns by its extensive reporting capabilities. The platform is connected online to the inspection system used at Striebig and RBAM and has been used for processing more than 80,000 cores during the demonstration phase to prove its operational value in a real business environment. By this, the identification, technical evaluation, and sorting results for every single core returned via the service can be reported in detail. By creating a unique selection ID (which Striebig and RBAM produce in the inspection process and mark the core with) the physical items are digitally connected to the commercial core return options in the platform. The technical and commercial return conditions of more than 30 suppliers of remanufactured automotive products for passenger cars as well as for commercial vehicles have been collected and incorporated into the platform. This includes all the major 1TL (first trade level) spare part OEMs as well smaller independent reman suppliers and can be considered the best market coverage available for automotive core returns in Europe.

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Both wholesalers intend to continue to use the service after the project ends. The service has also been offered successfully to an additional wholesaler which was not involved in the project activities. This shows that the existing service offer is already providing a very good value to automotive wholesalers. This is supported by the citation of a senior person of the management of one demonstrator: “Never ever did we have so few hassles with these topics!” The gained transparency and relieving the physical operations on the core management enables wholesalers to make informed decisions on the best usage of their cores and return options so that the complexity and hassle of handling used parts is not an obstacle to do business with reman products. The demonstrator has achieved its objective of creating an ICT platform that is capable of processing large number of cores and able to show the decoupling between the physical and financial flows.

The major developments have been the concept of transferable core return options, which helps in avoiding the financial losses and improves the allocation of used parts to the right stakeholders such as remanufacturers. This feature is both developed and validated during ReCiPSS project. The options-concept has been successfully demonstrated where the platform currently manages ~130.000 options and more than 100,000 options were exercised during demonstration phase.

Other prominent steps taken through the platform are incorporating more product/core types and their associated criteria for return. Initially, both remanufactures and wholesalers had their own set of core return challenges. On one hand the remanufacturers as producing companies are interested in a steady, predictable, and reliable reverse flow of cores to run the production. On the other hand, the wholesalers and buying groups of automotive spare parts in general are more concerned with managing the complexity and the effort resulting from the reverse logistics. The common challenges for both stakeholders in turn are the lack of transparency on the commercial situation and struggle to control their financial risks resulting from the financial incentives on cores.

Another useful feature implemented to create transparency over the core return options that was established for the wholesalers allowed them to compare and review credit notes, corresponding goods-out reports and exercised options easier. Furthermore, graphical reports give the platform user an overview of the available options and their date of expiry and potential for prolongation. For instance, the pie chart in the graphical reports summarizes the share of core return options between the different suppliers. The view can be switched between number of options or value of options, as well as between core return options or bank options, and finally between open, expired, and exercised options. Such features provide full transparency on the option portfolio to the platform users.

Additionally, the relevant data for a core was collected only once and redundant core inspections and decisions can be avoided as the cores were marked with a unique core tracking ID.

The outcomes of the project and the service offer has been presented to a professional audience of wholesalers, remanufacturers, and other stakeholders in an industry workshop as a side event to Automechanika 2022. The feedback collected out of this workshop can be seen in a word cloud shown in Figure 24.

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Figure 24: Word cloud from an industry workshop with the wholesalers

Moreover, demonstrator paved the way for new business opportunities by being a reference for other potential service users documenting that the service is functional and provides business value. With this trend the ReCiPSS platform started to achieve the status of a product or service that the stakeholders viewed as beneficial for their business.

A significant learning was that the technical rejection in automotive demonstration is not as significant as commercial rejection connected to expiry of options or unused options. Also, it could be seen during the demonstration phase of ReCiPSS, 10-20 % of options were unused. This leaves room for operational improvement to the benefit of higher core return rates. Overall, this complexity is addressed through the digital incorporation of commercial and technical rules in the automotive platform thereby facilitating the automotive stakeholders through high quality core management.

Furthermore, ReCiPSS has brought many learning opportunities for the automotive demonstrator and ideas for upscaling. There is an overall room for improvement when it comes to implementing digital solutions for the core management. There is an acceptance inertia towards the adoption of such solutions among the stakeholders. However, this can be resolved with communication and collaboration with the stakeholders in the automotive aftermarket by making the benefits explicit and visible to them in the form of digital solutions like the ReCiPSS platform. Further improvements can potentially lead to the addition of more remanufacturers, wholesalers and workshops and additional features that allow the planning for shortages (such as advanced inventory solutions).

To conclude, not least with the digital solutions, there are other benefits to gain through collaboration between the trade levels. The trust in core management will be strengthened by providing transparent information to all parties involved in the core management, the commercial value is better understood and estimated with enhanced visibility in the ReCiPSS platform. This in turn will pave the way for strengthening the circular economy within the remanufacturing business and improving the resource efficiency of materials in general.

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6. References

1. D7.1 Data management platform deployment report
2. D7.2 Core collection report
3. D7.3 Core identification, evaluation, and sorting report
4. D7.4 Core clearinghouse report

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