Research Report on the Dismantling Demonstration

14–15 April 2026

Vehicle Dismantling Test

Reforming Vehicle Recycling in the Sustainability Transition – A Low-Carbon Circular Economy Vehicle Dismantling Line Project

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ABSTRACT

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- Reforming Vehicle Recycling in the Sustainability Transition – A Low-Carbon Circular Economy Vehicle Dismantling Line Project

This study examines the feasibility of the end-of-life vehicle dismantling process and its time requirements in accordance with the European Union's proposed Regulation on End-of-Life Vehicles. The study was carried out as part of Turku University of Applied Sciences' *Reforming Vehicle Recycling in the Sustainability Transition – A Low-Carbon Circular Economy Vehicle Dismantling Line Project* (Vehicle Dismantling Line 2.0) and is based on a full-scale dismantling demonstration conducted at Autocirc's Nurmijärvi facility in April 2026.

The demonstration focused in particular on the requirements set out in Annex 7, Part C of the proposed regulation, which defines the parts and components that must be removed before vehicle shredding. The material was collected through detailed timing of work phases, mass measurements and documentation of the dismantling process. The complete processing of a single vehicle took 7 hours and 36 minutes, of which 6 hours and 34 minutes consisted of dismantling work.

The results indicate that dismantling in accordance with the regulation is technically feasible in the current dismantling environment but requires significantly more time and advance planning than current practices based on minimum requirements. Interior dismantling and dashboard removal in particular proved to be highly time-consuming. The process resulted in the recovery of 1,115 kg of material from a vehicle weighing 1,495 kg, including a significant quantity of critical raw materials such as copper. The results highlight the need for process development, digital tools and line-based processing solutions to support the economically sustainable implementation of the regulation.

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1 Introduction

The European Parliament and the Council have emphasised the need to improve the reusability, recyclability and recoverability of vehicles. The new Regulation on End-of-Life Vehicles focuses on the entire vehicle life cycle by promoting the implementation of circular economy principles from the manufacturing stage onwards. The latest proposal for the Regulation was published on 26 February 2026, and its objective is to repeal Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles.

The proposed regulation affects all stages of a vehicle’s life cycle by establishing the necessary measures from vehicle manufacturing through to end-of-life treatment. The Regulation on End-of-Life Vehicles supports the EU’s European Green Deal by reducing waste generated by the automotive industry, increasing circularity within the sector and helping to ensure the future availability of critical raw materials. (European Council, 2025).

The aim of Turku University of Applied Sciences’ *Reforming Vehicle Recycling in the Sustainability Transition – A Low-Carbon Circular Economy Vehicle Dismantling Line and Ecosystem* Project (hereinafter Vehicle Dismantling Line 2.0) is to develop new circular economy solutions and working methods for vehicle dismantling in cooperation with project stakeholders and partner companies. These include the non-destructive removal and reuse of components, source separation of materials and more efficient recycling of vehicle-derived materials.

This study examined the dismantling of an end-of-life vehicle at Autocirc’s Nurmijärvi facility in accordance with the new Regulation on End-of-Life Vehicles. The aim of the dismantling demonstration was to process the end-of-life vehicle in compliance with the requirements of the proposed regulation. Particular focus was placed on Annex 7, Part C of the regulation, which defines the mandatory parts and components that must be removed from end-of-life vehicles prior to shredding.

2 Legislation

At present, the treatment of vehicles at the end of their service life is not optimal from the perspective of extending the lifespan of high-quality vehicle components or improving material recycling. The treatment of ELVs (End-of-Life Vehicles) is currently based on the minimum measures required by legislation. When a vehicle is permanently withdrawn from road use, it undergoes depollution, during which fluids are removed, air-conditioning systems are emptied, and the catalytic converter, tyres and battery are removed. Following this pre-treatment process, the vehicle is shredded. (Haapala & Sinkonen, 2026).

The European Union's Regulation on End-of-Life Vehicles (European Council, 2026) introduces new requirements covering the entire vehicle life cycle. The regulation defines manufacturers' obligations, circular economy requirements for vehicles, and measures related to the treatment of end-of-life vehicles. Turku University of Applied Sciences' Vehicle Dismantling Line 2.0 project responds to the evolving legislative framework by researching and developing vehicle dismantling processes related to the reuse of high-quality components, the removal of vehicle parts, material separation and the enhancement of material recycling.

This study examined vehicle dismantling in accordance with the evolving legislative requirements. The dismantling demonstration focused on interpreting the new regulatory requirements, with particular emphasis on Annex 7, Part C of the regulation, which lists the mandatory parts and components that must be removed from end-of-life vehicles prior to shredding.

2.1 New Requirements Introduced by the Regulation

The new Regulation on End-of-Life Vehicles focuses on the entire vehicle life cycle by promoting the implementation of circular economy principles from the manufacturing stage onwards. The latest proposal for the regulation was published on 26 February 2026, and its objective is to repeal Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles. In addition, the new Regulation on End-of-Life Vehicles amends Regulation (EU) 2018/858 of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, as well as Regulation (EU) 2019/1020 of the European Parliament and of the Council on market surveillance and product compliance.

The regulation is divided into nine chapters addressing, among other topics, circular economy requirements for vehicles, manufacturers' obligations, the treatment of end-of-life vehicles, and matters related to implementation, delegated powers and legislative amendments. This report focuses in particular on Chapter 2: Circular Economy Requirements, Chapter 3: Manufacturers' Obligations and Chapter 4: Treatment of End-of-Life Vehicles.

2.1.1 Circular Economy Requirements

With regard to circular economy requirements, the legislation stipulates that vehicles must be designed and manufactured so that at least 85% of the vehicle is reusable or recyclable, and at least 95% is reusable or recoverable. Minimum requirements have also been established for certain substances and materials. For plastics, the regulation introduces a gradual transition towards a requirement that 25% of the plastic used in new vehicles must consist of post-consumer recycled plastic. One year after the regulation enters into force, the possibility of introducing minimum requirements for the proportion of recycled steel and aluminium used in new vehicles will also be assessed. Requirements relating to other metals will likewise be reviewed no later than three years after the regulation enters into force.

The circular economy requirements also include provisions on vehicle design to ensure that the parts identified in the regulation as mandatory for removal from ELVs are easily removable and replaceable. Vehicle components must be designed and installed in a manner that facilitates replacement, reuse, recycling, remanufacturing and refurbishment whenever technically feasible.

2.1.2 Manufacturers’ Obligations

Manufacturers are required to prepare a circular economy strategy describing the measures by which they will fulfil the circular economy requirements outlined above.

Cooperation across the entire value chain must be ensured through the maintenance of communication platforms for sharing updated information. Manufacturers are entitled to charge waste management operators, publishers of technical information, and repair and maintenance operators a reasonable and proportionate fee for maintaining these platforms.

2.1.3 Treatment of End-of-Life Vehicles

Chapter 4: Treatment of End-of-Life Vehicles addresses extended producer responsibility for vehicles, the collection of end-of-life vehicles, and the treatment of end-of-life vehicles.

Producers bear extended producer responsibility for vehicles that they place on the market in European Union Member States. They are responsible for ensuring that end-of-life vehicles are collected and treated in accordance with the regulation.

Authorised treatment facilities must ensure that all end-of-life vehicles, together with their parts, components and materials, are received and processed in accordance with the regulation. Treatment facilities are required to store and depollute received end-of-life vehicles in accordance with the minimum requirements. Before shredding, the parts and components listed in Annex 7, Part C of the regulation that have reuse, remanufacturing or refurbishment potential must be removed from the end-of-life vehicle.

2.1.4 Annex 7: Treatment Requirements

Annex 7 of the Regulation on End-of-Life Vehicles concerns the treatment of end-of-life vehicles. The annex is divided into Sections A–G, which set out the minimum requirements for the storage and depollution of end-of-life vehicles, as well as for the removal of parts and components and their reuse, remanufacturing and refurbishment in accordance with circular economy principles.

In the demonstration described in this report, the end-of-life vehicle was processed in accordance with Part C of the annex, which lists the mandatory parts and components that must be removed from end-of-life vehicles prior to shredding.

Part A defines the minimum requirements for the storage of end-of-life vehicles, with particular emphasis on environmental protection and preserving the integrity of parts and components. Part B sets out the minimum requirements for vehicle depollution and is broadly comparable to the current pre-treatment process carried out for end-of-life vehicles. In addition to the removal of fluids and gases, Part B also requires, for example, the removal and/or neutralisation of the eCall system and airbags.

Part C of Annex 7 lists all mandatory parts and components that must be removed from end-of-life vehicles. The table included in Part C also refers to Part G of the same annex, which defines requirements related to shredding and the use of post-shredding technologies. Part G establishes threshold values and quality requirements for metals recovered from post-shredding material. The removal of the components and parts listed in Part C is not mandatory if it can be demonstrated that post-shredding treatment technologies separate materials as effectively as manual or semi-automated dismantling processes and provided that the threshold values defined in Part G are met.

Table 1: Parts and Components to Be Removed Under Annex 7, Part C.

Parts and components to be removed	**Removal not required if the criteria set out in Part G are met**
Electric vehicle traction batteries, including battery management systems, on-board chargers, and associated casings and protective covers	
Batteries for light mobility vehicles, including battery management systems, chargers and protective structures	
Vehicle batteries	
Portable batteries or cells	
Electric motors, including protective covers, control units, connections, and associated parts and components	
Internal combustion engine blocks	X
Catalytic converters	
Gearboxes	X
At least 70% of glass material from windscreens and rear and side windows, including sunroofs	
Wheel rims	
Tyres	
Directly accessible infotainment system components	
Headlights and rear lights, including actuators	
Main wiring harnesses	X
Bumpers	X

Fuel tanks	X
Heat exchangers	X
Carbon fibre-reinforced plastic components	
Electrical and electronic components:	
inverters and DC/DC converters for electric vehicles weighing more than 2 kilograms	
easily accessible large, printed circuit boards	
solar panels with a surface area exceeding 0.2 square metres	
automatic transmission control modules and valve bodies	

Part D of Annex 7 defines the potential of parts and components for reuse, remanufacturing or refurbishment. A technical assessment must be carried out for removed parts and components. The technical assessment of parts and components intended for reuse ensures that the part is functional and readily suitable for its original intended purpose. Parts and components assessed for remanufacturing or refurbishment must include all relevant constituent elements. The assessment of remanufacturing and refurbishment potential must take into account damage, reduced functionality and performance, shortened service life, and any required repairs. The part or component must not exhibit visible corrosion that would impair its functionality. Part D of Annex 7 also promotes the traceability of vehicle parts and components by establishing minimum marking requirements. Parts and components intended for reuse, remanufacturing or refurbishment must be marked with the name of the part or component together with the necessary contact details of the treatment facility responsible for its removal.

Part E of Annex 7 lists the components and parts that are not suitable for reuse, such as airbags and complete seat belt assemblies.

Part F of Annex 7 establishes more detailed treatment requirements for removed parts, components and materials. Requirements concerning the treatment of certain parts, components and materials are laid down in other EU legislation referred to in Part F.

2.1.5 Evolving Interpretation

The updated EU regulation on end-of-life vehicles promotes circular economy principles within the automotive industry and supports the European Union's green transition and long-term material self-sufficiency. The Regulation on End-of-Life Vehicles establishes minimum targets for material circularity and strengthens the implementation of circular economy principles from the vehicle design stage onwards.

The regulation has not yet entered into force, and no official guidance on its interpretation has been published. The working group involved in this project sought to examine the regulation and the requirements it establishes. The dismantling demonstration designed and carried out as part of the project aimed to process the end-of-life vehicle from the perspective of Annex 7, Part C, which lists the mandatory parts and components to be removed.

At the time of writing this report, no Finnish-language translation of the latest version had been published. Earlier proposals are available in Finnish and were utilised during the planning phase and in the interpretation of the latest version of the regulation.

3 Planning Process for the Vehicle Dismantling Test

As part of Turku University of Applied Sciences' Vehicle Dismantling Line 2.0 project, the working group began planning vehicle dismantling demonstrations intended to generate practical information on the dismantling processes of end-of-life vehicles. Cooperation with companies operating in the sector helped guide the focus of the research towards areas with the potential to generate additional relevant information. Particularly in light of the new Regulation on End-of-Life Vehicles, potential research topics include the non-destructive removal of parts and components for reuse, remanufacturing or refurbishment. Other relevant topics include analysing practical dismantling processes through the measurement of dismantling times for parts and components, studying and improving work ergonomics, and examining logistics during and after dismantling for the sorting of parts, components and materials.

3.1 Scenario Model

The planning of the dismantling demonstration was based on the draft regulation published by the European Council on 11 June 2025, the scenario planning work initiated in autumn 2025 (Vehicle Dismantling and Material Circulation Scenario Study), and a previous vehicle dismantling test conducted by Turku University of Applied Sciences in 2025, which examined the complete dismantling of a vehicle. During the scenario planning process, the working group reviewed in detail the requirements and measures introduced by the new Regulation on End-of-Life Vehicles Based on these legislative requirements, various treatment scenarios were developed for vehicles arriving at dismantling facilities.

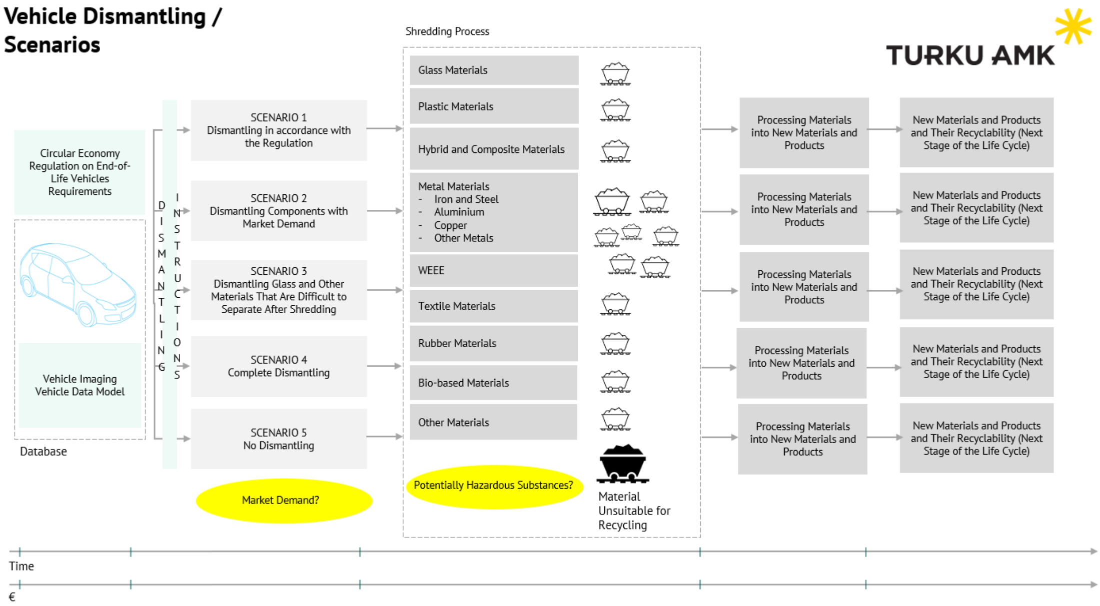


Figure 1. Vehicle dismantling scenario options.

Scenario 1 involved dismantling the vehicle strictly in accordance with the requirements defined in the regulation. The new regulation does not require the complete dismantling of vehicles but instead establishes minimum dismantling requirements. At the same time, the legislation places particular emphasis on high-quality material recycling, directing components towards reuse, and especially the mandatory recovery of critical raw materials before the vehicle body and remaining components are sent for shredding.

The overall structure of the test was developed on the basis of the requirements set out in the regulation, particularly Annex 7 Parts B, C, E and G, together with the working group’s extensive practical dismantling experience. In addition to the new draft regulation, the final dismantling plan and the practical priorities of the test were strongly influenced by the operational needs and preferences of the project partner Autocirc Nurmijärvi regarding the content of the demonstration.

3.2 Negotiations with Project Partners

During the spring, the content, practical arrangements and implementation of the dismantling test were further refined in cooperation with a working group consisting of specialists from Oili Jalonen Oy, Autocirc Nurmijärvi and the vehicle engineering department of Turku Vocational Institute. During joint planning meetings, it was agreed that the dismantling test itself would be carried out at Autocirc Nurmijärvi's facilities. It was further agreed that Autocirc would procure a vehicle for dismantling that would represent a sufficiently modern vehicle fleet in terms of age and technology. The practical dismantling work was assigned to one Autocirc employee and one automotive and transport engineering student from Turku University of Applied Sciences holding a vocational qualification in vehicle mechanics. The remaining members of the working group were assigned responsibility for detailed monitoring of the demonstration and timing of the work phases, documentation of the dismantling stages, and filming and recording of the work for subsequent analysis. At the conclusion of the planning phase, the demonstration was scheduled for 14–15 April, during which the dismantling test corresponding to Scenario 1 was carried out at Autocirc Nurmijärvi's facilities.

Prior to the sorting experiment, efforts were made to obtain access rights to the IDIS system (International Dismantling Information System), but without success. The system would provide up-to-date instructions for the treatment of end-of-life vehicles using model-specific information covering more than 70 vehicle manufacturers. At the time of writing this report, the organisation responsible for administering the system had not granted access rights to Turku University of Applied Sciences. Consequently, the system could not be utilised during the dismantling test.

3.3 Objectives of the Demonstration: Turku University of Applied Sciences

The purpose of the dismantling demonstration was to examine the effects of the new draft regulation on practical dismantling work. The objective was to follow

Annex 7, Part C of the regulation and thereby determine the dismantling times required for the removal of mandatory parts and components. Based on previous observations (Dismantling Test 2025), it was evident that the removal of several mandatory parts and components also required the prior dismantling of surrounding components. The aim was therefore to determine not only the time required to remove individual parts and/or components, but also the time required for the preceding work phases necessary for their removal.

In addition to timing individual work phases, measuring the total working time was considered particularly important. When examining the practical dismantling work, statutory employee breaks during the working day were also taken into account.

The dismantling demonstration was also intended to generate information for the Vehicle Dismantling Line 2.0 project to support the development of a circular economy-based vehicle dismantling line concept. The timing data collected during the test will be used to build a dismantling line simulation using Siemens Plant Simulation software. The development of the simulation and the analysis of material flows and dismantling process efficiency will be carried out as a separate study as part of the project results.

3.4 Objectives of the Demonstration: Autocirc Nurmijärvi

Autocirc Nurmijärvi’s primary objective was to determine how the increasingly stringent requirements of the forthcoming Regulation on End-of-Life Vehicles will affect day-to-day dismantling operations. The company’s business model is based on the removal and resale of reusable vehicle parts. As part of the study, the efficiency of existing operating models was also examined, including the time required for vehicle movements, parts classification, storage logistics and the dismantling process itself.

Autocirc is committed to promoting circular economy principles and resource efficiency within the automotive industry. Autocirc currently operates in seven countries through a network of 70 businesses. The selection of parts removed during the dismantling process was not based solely on the minimum requirements of the forthcoming Regulation on End-of-Life Vehicles. It was also strongly guided by Autocirc's own market data and by the requirements imposed by insurance companies in collision repair operations.

The company's real-time demand and sales data, together with insurance industry requirements, determined which parts and components were removed. Insurance company requirements were particularly reflected in the objective of removing pre-selected parts intact and in resale condition for reuse in collision repairs. As shown in the Autocirc component listing attached to this report (Appendix 1), a large number of parts and components were removed from the vehicle even though their removal is not required under the regulation prior to shredding.

3.5 Importance of Planning

The successful implementation of the dismantling demonstration required exceptionally careful and multi-stage advance planning. The revised Regulation on End-of-Life Vehicles introduces new and highly detailed requirements for the treatment of end-of-life vehicles. These requirements simultaneously affect the content of dismantling work, work sequencing, documentation practices, and the subsequent handling of removed parts and components. Without systematic planning, the practical application of the regulatory requirements to dismantling operations would have posed significant risks in terms of occupational safety, operational efficiency and the reliability of the research material.

The planning process began in autumn 2025 and was gradually refined in cooperation with Turku University of Applied Sciences, Turku Vocational Institute, Oili Jalonen Oy, Autocirc Nurmijärvi and other project stakeholders. A central objective was to structure the dismantling process in accordance with the new draft regulation, particularly Annex 7 Parts B, C, E and G, while ensuring that the process remained closely aligned with the practical realities of dismantling facilities. The aim was not to create an ideal dismantling process under laboratory conditions, but rather to produce a realistic demonstration reflecting future minimum regulatory requirements within a genuine industrial environment.

The importance of planning became particularly evident in the definition and scheduling of work phases. Before the demonstration, the working group defined which dismantling phases would fall within its scope, which work phases would be timed and at what level of precision, and how total working time would be related to individual work stages. This ensured that the collected timing data would be comparable, repeatable and suitable for future studies, particularly for dismantling line simulation and process optimisation. Without this detailed preparatory work, the measurement results would have remained isolated individual observations.

Planning also played a central role in occupational safety management and the allocation of responsibilities. A clear division of responsibilities was established between dismantlers, timekeepers, documenters and supervisors involved in the demonstration. Advance review of the work phases, written memoranda and joint planning meetings created the conditions for smooth communication during dismantling operations and reduced uncertainty during practical work situations. This proved particularly important in cases where work phases differed from initial assumptions due to vehicle damage or structural irregularities.

From a research perspective, the planning process enabled the project to generate not only descriptive material, but also analytically valuable data. The timed work phase data, detailed documentation of the dismantling sequence, and transparent recording of decision-making criteria created a dataset that can be used in future to assess the impact of the new regulation on dismantling duration, resource requirements and cost structures. This is particularly significant given that the draft regulation does not yet clearly define what constitutes unreasonable costs in dismantling operations.

Overall, the project demonstrated that careful planning is both a prerequisite for successful implementation and a central component of the research framework itself. Through systematic planning, the dismantling demonstration was closely linked to the broader objectives of the project, including the conceptualisation of dismantling lines, the evaluation of automation and digitalisation opportunities, and the anticipatory assessment of the impacts of future regulatory requirements. The planning process therefore formed the foundation for both reliable research data and practical development work.

3.6 Collection of Vehicle-Derived Glass

Vehicle glass was excluded from the scope of the dismantling demonstration. This decision was made for several reasons: the working group was unable to transport a glass collection trolley from Turku to Nurmijärvi and back, occupational safety considerations favoured avoiding glass breakage, and the working group already possessed extensive information on the collection of vehicle-derived glass from a previous demonstration. In addition, due to Autocirc’s operational practices, removed doors are stored intact as complete units.

Glass Recovery Test

In a previous project carried out by Turku University of Applied Sciences, vehicle-derived glass and its collection and recycling potential were examined separately. The project included a study investigating the recovery volumes of tempered glass from end-of-life passenger vehicles, the efficiency of the work process, and the purity level of the recovered material as part of the development of circular economy solutions for the automotive sector. The test was conducted during summer 2025 using 25 passenger vehicles, from which side and rear windows were recovered using a breakage-based collection method. Glass recovery was carried out using an emergency window hammer, and the glass fragments were collected using a glass collection trolley, bulk bag or plastic sheet. The recovered glass cullet was weighed using a pallet truck scale.

The results showed that an average of 12.4 kg of tempered glass was recovered per vehicle, excluding the windscreen. The average processing time was five minutes per vehicle. For windscreen removal, the fastest method proved to be cutting the windscreen using a reciprocating saw. The average removal time for a windscreen was approximately five minutes. When compared with previous tests achieving near-complete recovery rates, the breakage-based method achieved a recovery rate of approximately 75% for side windows and approximately 85% when the average weight of the windscreen was also taken into account. The purity level of the recovered glass was assessed as high; however, small fragments of rubber seals reduced the material classification to a chargeable reception category.

The study demonstrates that a breakage-based method enables rapid and quantitatively significant recovery of vehicle glass. However, further development is still required, particularly in the management of glass fragments, ergonomics, and ensuring material purity prior to industrial recycling.

4 Demonstration

The dismantling demonstration was carried out at Autocirc Nurmijärvi’s facilities on 14–15 April 2026. The dismantling process was performed by two dismantling workers. Other members of the project working group were present to record timings and document the process through video recording and photography. One person acted as supervisor and measured the total working time, another documented the timings of individual dismantling tasks, a third was responsible for the operation of the video recording equipment, and a fourth photographed the dismantling process in detail. Additional project staff members and trainees were also present to observe the demonstration and assist with photography and documentation.

The supervisor, together with Autocirc’s production manager, was responsible for occupational safety matters. Before the demonstration began, occupational safety procedures were reviewed, including emergency procedures in the event of fire and the required protective equipment for all personnel present in the area. Mandatory safety equipment included safety footwear, hearing protection, protective eyewear and high-visibility vests for supervisory personnel. In addition, the dismantling workers were required to wear suitable work clothing and protective gloves.

This section describes the individual work phases and the time required for each stage. Detailed working times are listed at the end of each section and are based on video analysis. Two working days were allocated for the demonstration, including statutory employee breaks. Breaks were excluded from the total working time measurements and are separately indicated in the video analysis records. Traditional stopwatches and smartphones were used for timing, while the working group’s smartphones and a laptop computer were used for video recording and photography. The video recordings were saved via a Teams meeting to the educational institution’s server, from which members of the working group were able to access and analyse the recordings.

4.1 Background of the Dismantling Workers

One dismantler was an employee of the company, while the other was a student assistant working on the Vehicle Dismantling Line 2.0 project and studying automotive and transport engineering at Turku University of Applied Sciences. The student also holds a vocational qualification in vehicle mechanics and had previous experience in vehicle dismantling. The Autocirc employee had worked in dismantling operations for one year and had previously worked in basic vehicle servicing.

4.2 Vehicle Information

- Volkswagen Passat 1.4.
- Model year: 2018
- Measured vehicle mass: 1,495 kg
- Final empty body shell mass: 380 kg
- The vehicle had sustained collision damage to the right front corner.
- Deformation was present at the end of the chassis rail and in the impact beam.
- The vehicle had been declared a total loss by the insurance company.

Although the collision damage had resulted in the vehicle being written off, the body damage had very little impact on the physical dismantling process. The damaged front support and impact structures were deformed only slightly, meaning that all bolted connections could still be opened normally. No parts or components were jammed or under tension and, consequently, no exceptional dismantling methods or destructive removal techniques were required. The damage was located in the right front corner and affected, in addition to the headlight and fog light, the bumper, right fender, wheel arch liner, bonnet, impact beam, radiator support frame and the end of the chassis rail.

4.3 Preparatory Stages of Dismantling

At 9:13 am, the vehicle was retrieved from the storage hall, where it had been placed after washing, and the measurement of the total dismantling time commenced. The progress of the process is described in detail in the following sections. The preparatory stages included vehicle testing, weighing, removal of the licence plates and photographic documentation. The vehicle had already been washed beforehand to save time and, consequently, washing was not included in the measured total working time.

4.4 Testing and Photography

Vehicle preparation began with testing to verify the functionality of systems such as the lights, sensors and audible warning devices. The vehicle was then lifted and lowered onto axle scales. The vehicle was then weighed and the measured mass recorded. Following this, the licence plates were removed. An Autocirc employee carried out comprehensive photographic documentation of the vehicle from all angles so that the vehicle information could be updated in the company’s systems. The time required for testing was not included in the video analysis because the testing was carried out outside the video recordings.

Testing required seven minutes, while the entire initial preparation phase took a total of 27 minutes.

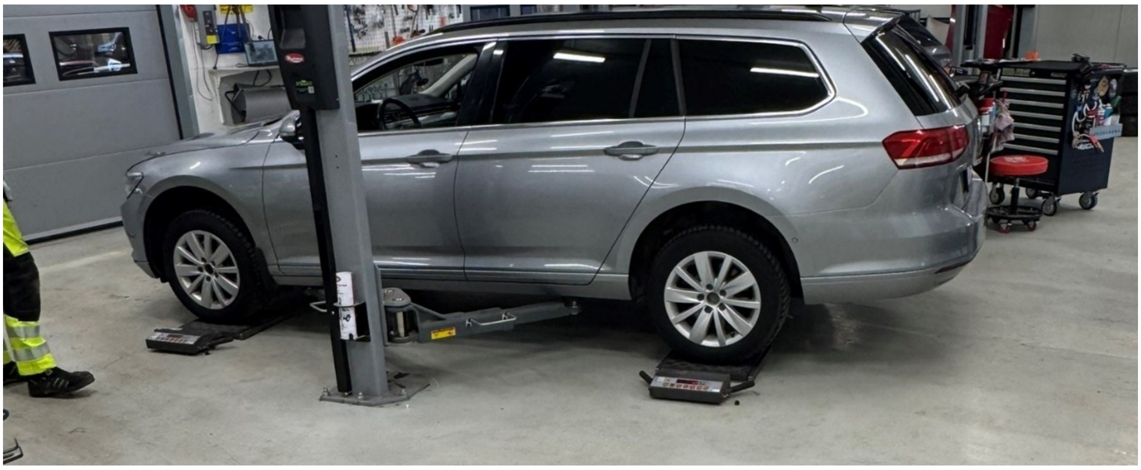


Figure 2 Vehicle weighing using axle scales

	Detailed Vehicle Dismantling Times					
Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
	First Dismantling Day, 14 April 2026					
Phase 1 – Testing, Weighing and Photography	Reversing the car into position, closing the warehouse door	9:20 AM	0:00:00	0:00:39	0:00:39	2
	Positioning the car on the lift		0:00:39	0:01:38	0:00:59	1
	Lifting the car, positioning the scales and lowering the car		0:01:38	0:03:21	0:01:43	2
	Reading and documenting the weights		0:03:21	0:03:50	0:00:29	2
	Lifting the car and removing the scales		0:03:50	0:05:10	0:01:20	2
	Moving the lift arms away, removing the licence plates		0:05:10	0:07:00	0:01:50	2
	Photography and labelling		0:07:00	0:09:40	0:02:40	1
	Moving the car and collecting the filming equipment		0:09:40	0:10:50	0:01:10	1
	Inspecting and photographing scratches on the doors		0:10:50	0:19:30	0:08:40	1
Work Phases from the Prot	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce

Figure 3 Working times for testing, weighing and photography

4.5 Door Removal

Following the preparatory stages, the dismantlers began the actual dismantling process. The first step involved removing the interior trim panels and side mirrors from the front doors. The side mirrors were removed intact because they were intended for resale as spare parts. After the mirrors had been removed, the front doors were detached first, followed by the rear doors. The doors were then loaded onto a designated storage rack in the warehouse area. Finally, the tailgate was removed and carried to its designated storage location in the warehouse. The windows were not removed separately from the doors because Autocirc stores doors as complete units and only dismantles them further once individual components or the doors themselves are sold. The project already includes timing data from previous tests concerning both the removal and breakage of side windows (Glass Recovery Test Report 2025). For occupational safety reasons, it was also preferred that the windows would not be intentionally broken, as this does not form part of Autocirc's normal operating practices. With two dismantling workers, the total time required for door removal was 35 minutes.

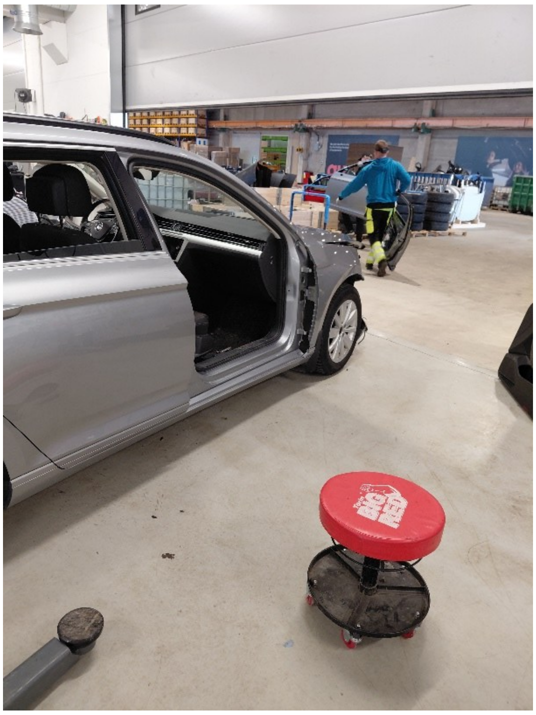


Figure 4. Door removal (left) and transfer from the dismantling area (right)

Figure 5. Door storage next to the dismantling hall

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
	Coffee break (approx. 30 min)					
Phase 2 – Side Mirrors, All Doors and Tailgate	Collecting tools and preparing the work	10:10 AM	0:00:30	0:02:55	0:02:25	2
	Removing the front door trim panel		0:02:55	0:04:45	0:01:50	1
	Removing the mirror		0:04:45	0:07:20	0:02:35	1
	Documenting and shelving the mirrors		0:07:20	0:09:07	0:01:47	1
	Removing the front door		0:09:07	0:10:55	0:01:48	1
	Documenting and removing the front doors from the work area		0:10:55	0:12:50	0:01:55	2
	Removing the rear door trim panel		0:12:50	0:14:47	0:01:57	1
	Removing the rear door		0:14:47	0:15:49	0:01:02	1
	Documenting and removing the rear doors from the work area		0:15:49	0:17:50	0:02:01	2
	Transition between work phases	10:28 AM	0:00:00	0:03:42	0:03:42	2
	Removing the tailgate trim panel		0:03:42	0:05:55	0:02:13	1
	Folding the rear seats, removing the parcel shelf and documentation		0:04:45	0:05:40	0:00:55	1
	Transition between work phases, discussion and tool changes		0:05:55	0:07:35	0:01:40	2
	Dismantling the tailgate into parts, documenting and shelving the components		0:07:35	0:15:15	0:07:40	2
	Removing and moving the tailgate aside		0:15:15	0:16:45	0:01:30	2
	Removing, documenting and shelving the rear lights		0:16:45	0:18:49	0:02:04	2
	Collecting tools onto the trolley, transition between work phases		0:18:49	0:20:10	0:01:21	2

Figure 6 Working times for side mirrors, doors and tailgate

4.6 Vehicle Depollution

Following door removal, all fluids were extracted from the vehicle and collected into the tanks of the depollution system, after which the quantities were recorded. As most fluids are removed from underneath the vehicle through draining, the vehicle was first lifted and the necessary equipment positioned beneath it. Depollution began with draining the engine oil and transmission oil into a shared oil extraction unit. At the same time, the oil filter was removed and allowed to drain into the same collection container. Autocirc used a pneumatic depollution and extraction system that transferred collected substances through hoses into dedicated storage containers. Using this system, coolant and brake fluid were recovered from the vehicle. The refrigerant from the air-conditioning system was removed through the service ports using an air-conditioning service unit. Fuel removal was carried out using a fuel tank draining device that combined a drill for puncturing the fuel tank with a sealed suction head for extracting the fuel. The removed fluids were recorded either by mass or volume, and all punctured tanks were sealed to prevent leakage. The depollution stage required a total of 40 minutes.

Figure 7. Depollution equipment (left) and fuel extraction system (right)

While depollution was in progress, the dismantlers were also able to remove underbody plastic components simultaneously, as the vehicle had already been lifted for fluid draining. The removal of the underbody plastics required 13 minutes and was completed entirely during the depollution stage.

Figure 8. Removal of underbody plastics

	Collecting tools onto the trolley, transition between work phases		0:18:49	0:20:10	0:01:21	2
Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phases 3 + 4 – Depollution and Removal of Underbody Plastics	Preparation for depollution, discussion, collecting equipment	10:48 AM	0:00:00	0:06:42	0:06:42	1
	Documenting and removing the tailgate from the work area		0:02:49	0:03:33	0:00:44	2 + 1
	Depollution started, draining engine and transmission oils		0:06:42	0:28:30	0:21:48	1
	Preparing the pneumatic depollution system		0:07:54	0:09:00	0:01:06	1
	Removing brake fluid (rear right)		0:09:00	0:28:11	0:19:11	1
	Removing coolant		0:09:26	0:30:33	0:21:07	1
	Removing and draining the oil filter		0:10:02	0:10:33	0:00:31	1
	Collecting and preparing the fuel extraction system		0:13:34	0:17:32	0:03:58	1
	Removing fuel		0:17:32	0:24:48	0:07:16	1
	Removing front and rear underbody panels and screws		0:23:19	0:24:21	0:01:02	1
	Removing the remaining underbody plastic components		0:24:45	0:35:40	0:10:55	1
	Plugging the fuel tank, removing equipment from the work area, weighing		0:24:48	0:27:06	0:02:18	1
	Removing brake fluid (rear left)		0:28:21	0:31:35	0:03:14	1
	Plugging the engine and transmission oil channels, wiping spills		0:28:30	0:30:19	0:01:49	1
	Removing the oil collection container and documenting the collected oil		0:30:44	0:31:30	0:00:46	1
	Removing brake fluid (front right)		0:31:46	0:33:12	0:01:26	1
	Removing brake fluid (front left)		0:33:23	0:35:51	0:02:28	1
	Depollution completed, lowering the car, transition between work phases		0:35:51	0:37:18	0:01:27	2

Figure 9 Working times for depollution and removal of underbody plastics

4.7 Exterior Body Plastics, Bumpers and Radiator Cores

During the next stage, the dismantlers began removing large plastic components, such as bumpers and other exterior body plastics. At the same time, the left headlight assembly, including its control units, was removed from the vehicle. The right headlight was unsuitable for reuse because the vehicle had sustained collision damage to the right front corner. For the same reason, the front bumper was also unsuitable for reuse. During this stage, the radiator cores located in the engine bay were dismantled and the remaining fluid reservoirs emptied. The radiator cores associated with the engine, air-conditioning system and intercooler circulation systems were removed from the front support structure in order to recover the aluminium core material. The windscreen washer fluid was collected, its volume estimated and the quantity recorded. Overall, this stage required 40 minutes.

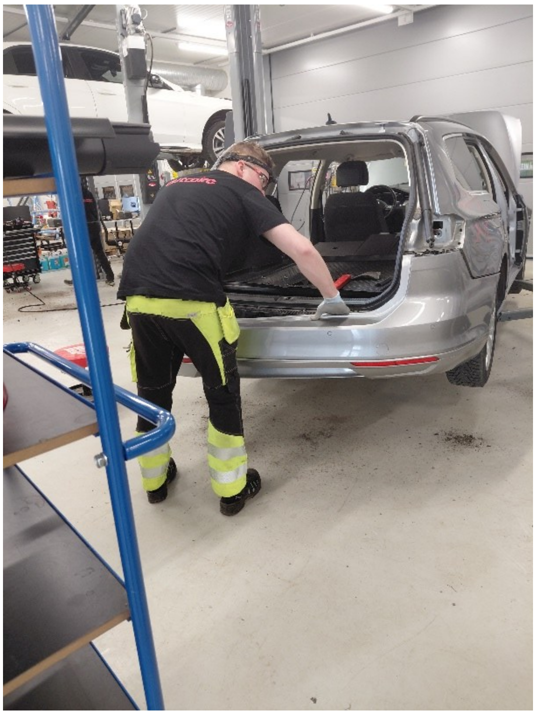


Figure 10. Removal of the rear bumper (left) and front radiator assembly (right)

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
	Lunch break (approx. 54 min)					
Phase 5 – Removal of Exterior Body Plastics, Bumpers and Radiator Core	Preparation for the next phase	12:30 PM	0:00:00	0:00:40	0:00:40	2
	Removing the rear bumper plastic section		0:00:40	0:05:21	0:04:41	1
	Collecting and connecting the air-conditioning service unit to the car		0:00:44	0:03:17	0:02:33	1
	Removing the front grille		0:03:17	0:03:47	0:00:30	1
	Removing the front bumper plastic section (+ part of the engine bay)		0:03:47	0:07:04	0:03:17	1
	Removing the rear bumper fasteners		0:06:43	0:09:56	0:03:13	1
	Removing the left headlight		0:07:04	0:09:03	0:01:59	1
	Documenting and shelving the headlight		0:09:03	0:09:53	0:00:50	1
	Documenting and shelving the removed rear fasteners		0:09:56	0:13:02	0:03:06	1
	Removing the damaged headlight, discussion, transition between work phases		0:09:53	0:15:50	0:05:57	1
	Discussion, transition between work phases		0:13:02	0:15:43	0:02:41	1
	Removing, documenting and shelving the parking sensor bar		0:15:43	0:18:05	0:02:22	1
	Removing the rear bumper impact beam		0:18:05	0:19:02	0:00:57	1
	Documenting and shelving the impact beam		0:19:02	0:19:52	0:00:50	1
	Preparing for radiator removal, removing plastics, draining fluids		0:15:50	0:20:21	0:04:31	1
	Removing the front bumper impact beam and radiator		0:20:21	0:25:25	0:05:04	2
	Lifting the car, transition between work phases	12:56 PM	0:02:57	0:03:41	0:00:44	2
	Removing, documenting and shelving the side skirt trims		0:03:41	0:09:17	0:05:36	2
	Documentation		0:09:17	0:10:18	0:01:01	1
	Removing the windscreen washer fluid reservoir		0:10:18	0:12:13	0:01:55	1
	Draining and documenting the windscreen washer fluid		0:12:13	0:13:03	0:00:50	1
	Discussion, removing parts from the work area, transition between work phases		0:13:03	0:14:24	0:01:21	2
	Preparation for the next phase	1:08 PM	0:00:00	0:00:33	0:00:33	2
	Dismantling the radiator into parts, removing the aluminium core		0:00:33	0:03:51	0:03:18	2
	Documenting and shelving the radiator and front bumper parts		0:03:51	0:07:13	0:03:22	2
	Cleaning, waste removal, discussion, transition between work phases		0:07:13	0:14:23	0:07:10	2

Figure 11 Working times for the removal of exterior body plastics, bumpers and radiator cores

4.8 Bonnet Removal

At this stage, the dismantlers decided to remove the bonnet, which was transferred to storage pending possible resale. After the bonnet had been moved to storage, smaller dismantling tasks were carried out in the engine bay area. One dismantler removed the windscreen wipers and the lower windscreen cowl panel, while the other worked in the front fender area. This stage required 10 minutes.

Figure 12. Bonnet removal

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phase 6	**Removing and carrying away the bonnet**		0:14:23	0:16:27	0:02:04	2
	Removing the wipers and mechanisms, working on the left front corner are	1:24 PM	0:00:49	0:08:55	0:08:06	2
	Discussion, transition between work phases		0:08:55	0:13:22	0:04:27	2

Figure 13 Working times for bonnet removal

4.9 Partial Interior Dismantling and Seat Removal

At this point, the dismantlers carried out separate tasks simultaneously, as two workers could not efficiently perform the same task within the confined workspace. One dismantler began dismantling the interior from the luggage compartment area, while the other worked on the dashboard, which is described in the following section. All removable trim materials and seat belts were removed from the luggage compartment area. During the second part of the stage, the rear seats were removed to allow the remaining interior trim components to be dismantled. Finally, the front seats were removed, with both dismantlers working simultaneously on the task. After this stage, both dismantlers continued working together on dashboard removal. The partial interior dismantling and seat removal stage required a total of 39 minutes. Dashboard dismantling work was carried out simultaneously throughout this entire period.

Figure 14. Dismantling of the luggage compartment interior and dashboard work

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phase 9	**Initial dashboard dismantling, steering wheel removal, documentation and shelving**		0:12:32	0:42:14	0:29:42	1
Phase 7	**Initial dismantling of quickly removable luggage compartment interior components**		0:13:22	0:23:03	0:09:41	1
Phase 8 – Seats	**Initial removal of the rear seats and continuation of interior dismantling**		0:23:03	0:42:14	0:19:11	1
	Final removal of the rear seats		0:42:14	0:45:55	0:03:41	2
	Removing the front seats		0:45:55	0:49:35	0:03:40	2

Figure 15 Dashboard work, seat removal working times, etc.

4.10 Dashboard Removal and Completion of Interior Dismantling

The most labour-intensive stage of the dismantling process was dashboard removal, as no manufacturer instructions were available for the procedure and several additional work stages were required in order to remove the dashboard intact. The dashboard was removed intact because Autocirc intended to offer the plastic dashboard housing for reuse. Dashboard dismantling was initially carried out by one dismantler and, after completion of the previous stage, by two dismantlers working together. During dismantling, it became apparent that the gear selector prevented the dashboard from being removed from the vehicle. The gear selector could not be removed from above, which required access to the underside of the vehicle. Consequently, the vehicle had to be temporarily lifted. Part of the exhaust system first had to be cut away from underneath the vehicle using a pneumatic cutting tool before the gear selector could be accessed and removed. The dashboard was ultimately removed successfully from the vehicle. The work initially required 37 minutes with one dismantler, including simultaneous seat removal work, followed by a further 42 minutes with two dismantlers, including removal of the gear selector. In total, including all additional work stages, dashboard removal required 1 hour and 23 minutes.

Between the dashboard removal stages, work was also carried out on the centre console, which was removed from the vehicle as a single unit, documented and placed into storage. At the same time, the seat belts were removed and the remainder of the interior dismantled down to the body floor carpeting. This stage required 16 minutes, during which both dismantlers worked partly on separate areas within the vehicle body.

Figure 16. Work on the dashboard and centre console and completion of interior dismantling.

The first day was completed at this stage, with a total accumulated working time of 4 hours and 50 minutes.

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phase 10 – Interior Dismantling	**Front interior dismantling, centre console removal**		0:49:35	0:58:53	0:09:18	1
	Front interior dismantling, seat belt removal, documentation and shelving		0:49:35	1:03:27	0:13:52	1
	Inspection, documentation and shelving of the centre console, transition between work phases		0:58:53	1:00:46	0:01:53	1
	Removing the glove compartment		1:00:46	1:06:00	0:05:14	1
	Removing waste from the work area, working on the centre console base		1:03:27	1:06:00	0:02:33	1
Coffee break (approx. 25 min)						
Phase 9 – Dashboard	**Removing the dashboard (gear selector prevents removal)**	2:55 PM	0:00:00	0:26:42	0:26:42	2
	Initial removal of the gear selector, lifting, cutting the exhaust pipe		0:26:42	0:31:30	0:04:48	2
	Removing the gear selector, removing floor panels		0:31:30	0:34:50	0:03:20	2
	Finalising dashboard removal and lifting it out, lowering the car		0:34:50	0:40:30	0:05:40	2
Final cleaning and end of the day	Collecting tools, cleaning the interior, discussion		0:40:30	0:50:45	0:10:15	2
	Final cleaning, drying spills, removing waste, end of the day		0:50:45	1:02:27	0:11:42	2
	End of the day	3:57 PM				

Figure 17 Working times for dashboard and gear selector removal

4.11 Removal of the Main Body Wiring Harness, Pyrotechnic Devices and Wheels

The second day began by completing the dismantling of the vehicle interior. Some interior components still remained to be removed, and the floor carpeting had to be taken out to access the main body wiring harness. A box of copper wiring was recovered from the vehicle, and its weight was measured and recorded. The headliner had to be removed in order to detach the electric motors of the powered tailgate, remove the remaining wiring, and access the pyrotechnic devices. During this stage, the second dismantler also removed the wheels from the vehicle. Removal of the main body wiring harness and completion of interior dismantling were carried out primarily by two dismantlers and required a total of 38 minutes. Wheel removal required 5 minutes and was completed entirely during this stage as a parallel activity.

Figure 18. Removal of the grab handle to allow headliner removal (left) and airbag removal (right)

Figure 19. Interior fully dismantled

Figure 20. Wheel removal

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Second Dismantling Day, 15 April 2026						
Phase 11 – Main Body Wiring Harness and Pyrotechnic Devices	Lowering the car to floor level	9:20 AM	0:00:00	0:00:47	0:00:47	2
	Removing the front interior floor carpet		0:00:47	0:01:57	0:01:10	1
	Documenting, removing and shelving the tailgate gas struts		0:00:47	0:02:23	0:01:36	1
	Removing the main body wiring harness, including dismantling of the headliner		0:02:23	0:07:30	0:05:07	2
	Transition between work phases		0:07:30	0:08:10	0:00:40	2
	Removing grab handles, pyrotechnic devices and the headliner		0:08:10	0:24:50	0:16:40	2
	Cleaning the body shell, tool changes, transition between work phases		0:24:50	0:25:40	0:00:50	2
	Completing the dismantling of the body interior		0:25:40	0:34:05	0:08:25	1
	Collecting tools and preparing the work, discussion, transition between work phases		0:25:40	0:29:02	0:03:22	1
Phase 12	**Removing the wheels and carrying them away**		0:29:02	0:34:03	0:05:01	1
	Discussion, transition between work phases		0:34:05	0:36:05	0:02:00	2

Figure 21 Working times for removal of the main body wiring harness, interior dismantling and wheels

4.12 Removal of the Powertrain, Axles, Catalytic Converter and Exhaust System

Once the interior had been completely dismantled, work proceeded to the removal of the powertrain, axles, catalytic converter and exhaust system. The greatest amount of work during this stage was associated with disconnecting the hoses and wiring connected to the engine and transmission, as these formed a complex and tightly packaged assembly. The subframe bolts were removed from the body, a pallet was positioned beneath the powertrain, and the vehicle was lowered. Checks were then carried out to ensure that no hoses or wiring remained connected and that the engine and front axle assembly rested securely on the pallet. Finally, the engine and transmission mounts together with the upper mounting points of the suspension struts were detached, allowing the powertrain to remain on the pallet together with the subframe and front suspension assemblies. The body shell was then carefully lifted to allow removal of the pallet, while the ABS sensor wiring connected to the front axle was cut. During this process, the fenders were also removed and all shock absorber mountings detached from the body. According to Annex 7 Parts C and G of the draft regulation, the powertrain and axle assemblies could have remained in the vehicle for shredding; however, in this case they were removed for reuse.

Figure 22. Powertrain and front axle assembly removed onto a EUR pallet

The same procedure was carried out for the rear axle, which was removed onto its own EUR pallet. While the vehicle remained lifted on the hoist, the catalytic converter and exhaust system were also removed from underneath the vehicle and directed to material recycling. Overall, this work stage required a total of 39 minutes with two dismantlers.

Figure 23. Rear axle removed onto a EUR pallet

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phase 13 – Powertrain, Axles, Catalytic Converter and Exhaust System	**Cutting powertrain hoses, removing structural bolts**		0:36:05	0:45:58	0:09:53	2
	Lifting the car		0:45:58	0:46:34	0:00:36	2
	Removing the fenders		0:46:34	0:48:42	0:02:08	2
	Discussion, collecting and preparing the hydraulic support device		0:48:42	0:50:10	0:01:28	2
	Removing the rear axle shock absorbers from the body		0:50:10	0:51:39	0:01:29	2
	Lifting the car, collecting pallet trucks, transition between work phases		0:51:39	0:53:15	0:01:36	2
	Removing front axle bolt fixings from underneath the body		0:53:15	0:54:45	0:01:30	2
	Positioning the EUR pallet under the engine, lowering and positioning the car		0:54:45	0:56:02	0:01:17	2
	Removing the final bolts, cutting ABS sensors, lifting the body	10:16 AM	0:00:00	0:02:42	0:02:42	2
	Removing items from the work area, discussion, transition between work phases		0:02:42	0:06:52	0:04:10	2
	Removing rear axle mounting bolts, disconnecting connections		0:06:52	0:10:10	0:03:18	2
	Positioning the EUR pallet under the axle, lowering the body		0:10:10	0:11:30	0:01:20	2
	Removing the final rear axle bolts and lowering the axle onto the pallet		0:11:30	0:13:13	0:01:43	1
	Removing the rear axle from the work area		0:13:13	0:15:19	0:02:06	1
	Discussion		0:11:30	0:15:19	0:03:49	1
	Discussion, preparing the pneumatic cutter, transition between work phases		0:15:19	0:16:40	0:01:21	2
	Removing and carrying away the catalytic converter		0:16:40	0:17:36	0:00:56	2
	Removing and carrying away the exhaust system		0:17:36	0:18:25	0:00:49	2
	Discussion, transition between work phases		0:18:25	0:19:50	0:01:25	2

Figure 24 Working times for removal of the powertrain, axles, catalytic converter and exhaust system

4.13 Removal of the Fuel Tank and Engine Bay Main Wiring Harness

While the vehicle remained lifted, the fuel tank and auxiliary fluid tanks were removed from underneath the vehicle. Removal of these components required 5 minutes. The vehicle was then lowered, and the remaining sections of the main wiring harness were removed from the engine bay. This work required 7 minutes with two dismantlers. The final component removed was the fuel filler flap, which was retained for reuse. Following this stage, the vehicle had been fully dismantled, and the body shell was ready for transport to the shredding container. In total, this work stage required 15 minutes.

Figure 25. Removal of the fuel tank

Figure 26. Removal of the engine bay main wiring harness

At this point, the second dismantling day was considered complete at 10:53 am. The work area still required cleaning and the recovered materials had to be weighed and documented. A total of 11 minutes of working time was allocated to final cleaning activities. At the conclusion of the dismantling process, the body shell was weighed using three axle scales, with wooden blocks used to stabilise and level the body on the scales. The final weighing was carried out to determine the mass of material removed from the vehicle; however, this stage is unlikely to be required under the final version of the regulation. The final body shell mass was 380 kg, meaning that a total of 1,115 kg of material had been removed from the vehicle. A total of 13 kg of copper wiring was recovered. Timing was stopped at 11:05 am, resulting in a total dismantling working time of 6 hours and 34 minutes.

Figure 27. Fuel tank removed and exhaust system dismantling in progress

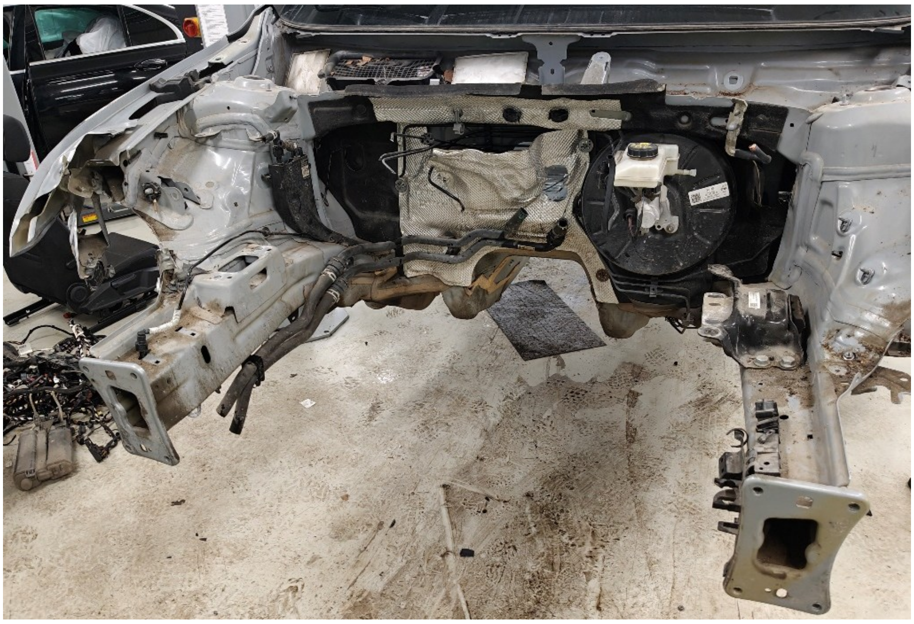


Figure 28. Engine bay main wiring harness removed

Figure 29. Remaining body shell

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Phase 14	**Removing and carrying away the fuel tank**		0:19:50	0:24:12	0:04:22	2
	Lowering the car, transition between work phases		0:24:12	0:25:13	0:01:01	2
Phase 15	**Removing the engine bay main wiring harness**		0:25:13	0:32:13	0:07:00	2
	Discussion		0:32:13	0:33:57	0:01:44	2
Phase 16	**Removing and carrying away the fuel filler flap**		0:33:57	0:35:35	0:01:38	2
	Discussion, transition between work phases		0:35:35	0:39:01	0:03:26	2
Final cleaning	Final cleaning, waste removal, weighing and documentation		0:39:01	0:43:14	0:04:13	2
	Final cleaning, waste removal, weighing and documentation	11:00 AM	0:00:00	0:04:40	0:04:40	2
	Final weighing of the body shell (not a direct timed operation)	11:07 AM	0:06:55	0:10:38	0:03:43	2

Figure 30 Working times for removal of the fuel tank, fuel filler flap and engine bay main wiring harness

4.14 Removal of the Body Shell and Further Dismantling of the Dashboard and Powertrain

Following completion of the vehicle dismantling process, the working group discussed subsequent processing activities for the largest removed assemblies and whether these stages should also be included in the time measurements. The Regulation on End-of-Life Vehicles requires the removal of directly accessible infotainment system components from the dashboard. Disassembly of the powertrain into smaller assemblies is not mandatory, as the powertrain may be sent for shredding together with the body shell (Annex 7, Part G of the regulation). However, Autocirc was interested in measuring the time required for further disassembly and in assessing the feasibility of reselling the engine as a complete unit. The working group therefore decided to continue timing the transport of the body shell from the workstation to the shredding container, the complete dismantling of the dashboard into smaller reusable assemblies without damage, and the separation of the engine and front axle into individual assemblies.

Measurement of total working time was restarted once the loader arrived to collect the body shell. The body shell was transported to the storage area adjacent to the dismantling hall, where the loader transferred it into a container for shredding. The body shell was transferred without removing the windscreen, as windscreen removal was considered undesirable for occupational safety reasons and does not form part of Autocirc’s standard operating practices. The project already contains measured windscreen removal times from earlier studies (Glass Recovery Test Report 2025). Timing for this work stage was stopped once the loader had completed the operation, resulting in a measured duration of just under four minutes.

Figure 31. Removal of the body shell

Following this, the dismantlers proceeded with two parallel work streams: one focused on dismantling the dashboard and the other on disassembling the powertrain. For the dashboard, the objective was to remove the components intact. The first major stage involved separating the large dashboard plastic housing from the remaining assemblies. The plastic housing was successfully separated after 29 minutes of work, during which the dismantler also assisted the second worker for approximately 4 minutes. Subsequent timing measurements covered removal of the metal frame, recovery of the air-conditioning heat exchanger core material, and removal of the fuse box. At the end of the work, WEEE waste was sorted into a dedicated collection container. Including all work stages, complete dismantling of the dashboard into individual components required a total of 49 minutes.

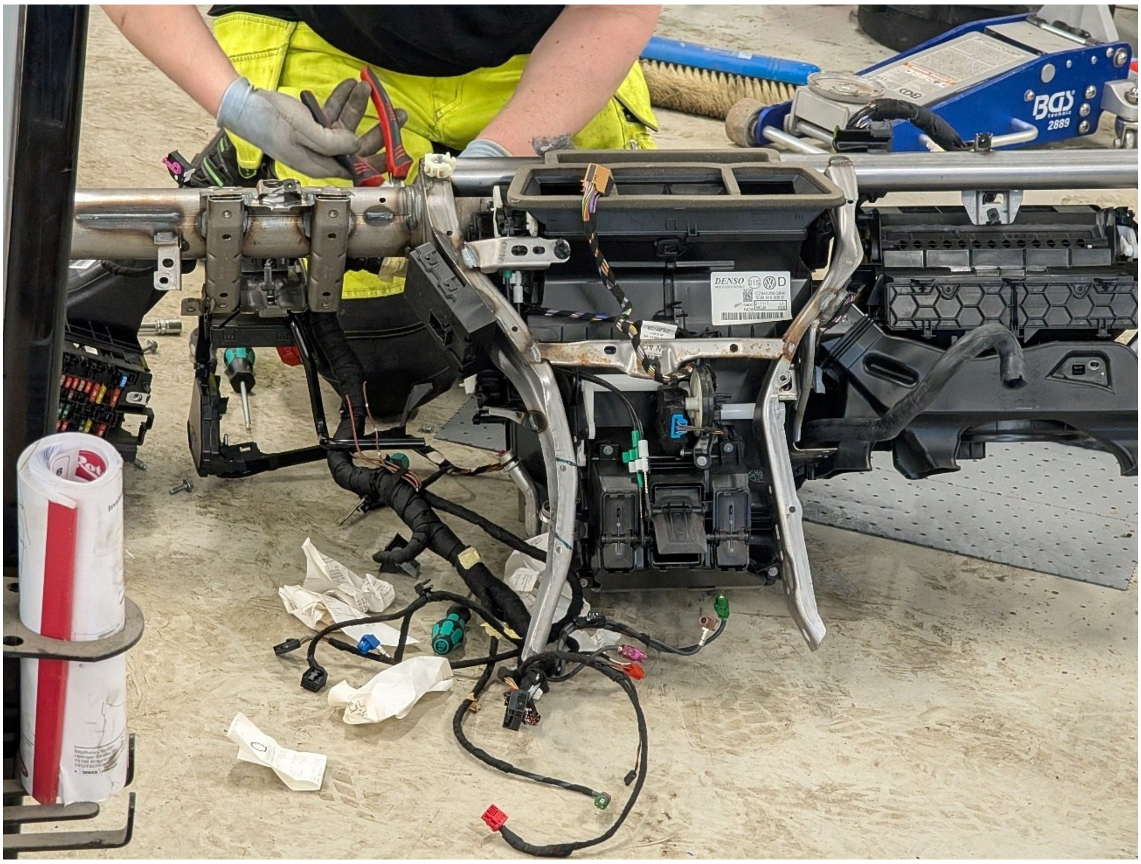


Figure 32. Dashboard dismantling

Disassembly of the powertrain began with separating the left suspension strut from the steering knuckle. Shortly after work commenced, it became evident that dismantling the front axle assembly was challenging and required considerable physical effort. The dismantler had to retrieve wooden blocks to provide stable support for the axle components on the pallet and repeatedly raise and lower the powertrain assembly to improve component positioning and access. Due to these challenges, the work was ultimately discontinued, as component removal became particularly difficult when the assemblies remained unstable and could not be adequately supported during dismantling. By the time work was halted, removal of the first suspension strut had required 39 minutes, and total elapsed working time had reached 50 minutes.

Figure 33. Powertrain disassembly

Autocirc agreed to complete the remaining dismantling work independently and continue recording the time required from that point onwards. According to information provided to the working group, the engine and transmission were subsequently separated, followed by removal of the front axle beam, suspension struts, steering rack, driveshafts and steering knuckles. Removal of these remaining assemblies required an additional 48 minutes.

Dismantling activities concluded at 13:28, after which the work area was cleaned and WEEE waste was weighed. Timing was stopped at 1:31 pm, resulting in a total accumulated working time of 7 hours and 36 minutes.

Work Phases	Dismantling Operation	Timestamp in Video	Start Time	End Time	Duration	Workforce
Additional Work Phases After Vehicle Dismantling	**Removing the body shell from the work area (from loader contact to return t**	12:29 PM	0:06:43	0:11:27	0:04:44	2
	Initial removal of the plastic housing, documentation of several parts		0:13:32	0:26:44	0:13:12	1
	Dismantler assisting with dismantling another subassembly		0:26:44	0:30:41	0:03:57	1
	Finalising removal of the plastic housing and removing it from the work area		0:30:41	0:43:15	0:12:34	1
	Documenting and shelving the removed parts		0:43:15	0:45:52	0:02:37	1
	Metal frame removed		0:45:52	0:51:17	0:05:25	1
	Removing the air-conditioning core		0:51:17	0:57:26	0:06:09	1
	Air-conditioning core removed	1:20 PM	0:00:00	0:00:46	0:00:46	1
	Intermediate cleaning		0:00:46	0:02:20	0:01:34	1
	Removing the fuse box		0:02:20	0:05:47	0:03:27	1
	Removing the first front axle suspension strut		0:16:17	0:55:33	0:39:16	1
	Working on the second suspension strut (compiled partly from two videos)		0:55:33	1:03:26	0:07:53	1
	Final cleaning and weighing of WEEE waste		0:07:38	0:12:39	0:05:01	2
	End of the day	1:31 PM				

Figure 34 Working times for body shell removal and dismantling of the dashboard, engine and front axle assemblies

4.15 Documentation and Further Processing of Removed Parts

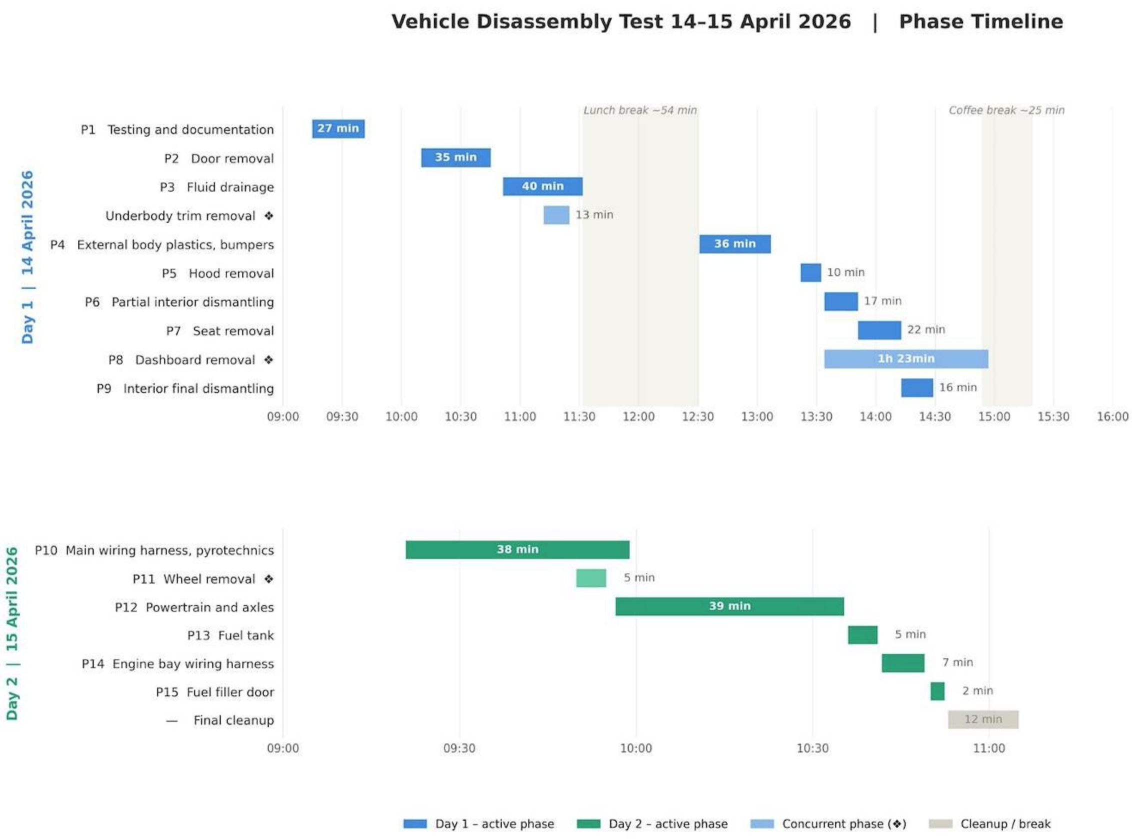
Once the majority of vehicle parts had been dismantled and transferred onto a rolling storage rack, the components were taken for cleaning. Cleaning of the removed parts was carried out by an Autocirc employee and required approximately 39 minutes. The rolling rack was then moved to the photography and packaging station, after which the employee began labelling the dismantled parts with identification tags. This stage required approximately 20 minutes, during which the employee also had to retrieve an additional pallet.

Following cleaning and labelling, the process proceeded to the photography stage, as the dismantled components were intended for resale. The photographed components included, among others, side mirrors and rear lights. Photographing all components required approximately 26 minutes.

After the photography stage, the components were packaged and-documented to prepare them for sale and further processing. This stage required 1 hour and 11 minutes. The total duration of the post-processing activities was 162 minutes.

No parts or components were directed to remanufacturing and/or refurbishment; all removed components were either prepared for reuse or directed to material recycling. The assessment was carried out by an Autocirc employee with support from the production manager. Component classification and dismantling decisions were significantly influenced by the fact that the vehicle had sustained collision damage and had been declared a total loss by the insurance company.

Table 2. Timeline of Work Phases



5 Results

The dismantling demonstration was conducted at Autocirc Nurmijärvi on 14–15 April 2026 and involved the processing of a single end-of-life vehicle. The findings are based on timed work data collected during the dismantling operation, mass measurements, documented work phases and direct observation of the process. The results examine the practical feasibility of carrying out dismantling in accordance with the proposed regulation, the temporal distribution of individual work stages, and the overall material and research outcomes generated through the demonstration.

5.1 Total Duration of the Dismantling Process

Processing the vehicle in accordance with the proposed regulation, including depollution, removal of mandatory parts and components, material sorting, and documentation of key assemblies, required a total of 7 hours and 36 minutes. This duration includes dismantling activities carried out by two workers as well as supplementary post-dismantling operations, including washing, photographing and documenting components for resale or further processing.

The core dismantling operation, including processing of the body shell, required approximately 6 hours and 34 minutes. Additional activities performed after completion of the main dismantling process, including further dismantling of the dashboard and powertrain assemblies and related documentation, extended the total duration to the value reported above. The findings indicate that dismantling in accordance with Annex 7 Part C of the proposed regulation is substantially more time-intensive than current dismantling practices based on minimum regulatory requirements.

5.2 Temporal Distribution of Work Stages

Analysis of the timed work stages showed that interior dismantling and dashboard removal accounted for the largest proportion of total working time. Removal of the dashboard while preserving component integrity was identified as the single most time-intensive stage of the entire demonstration, requiring a total of 1 hour and 23 minutes. This stage proved particularly demanding because model-specific dismantling instructions for the vehicle were unavailable, resulting in additional operations and requiring structural assessment and problem-solving during the dismantling process.

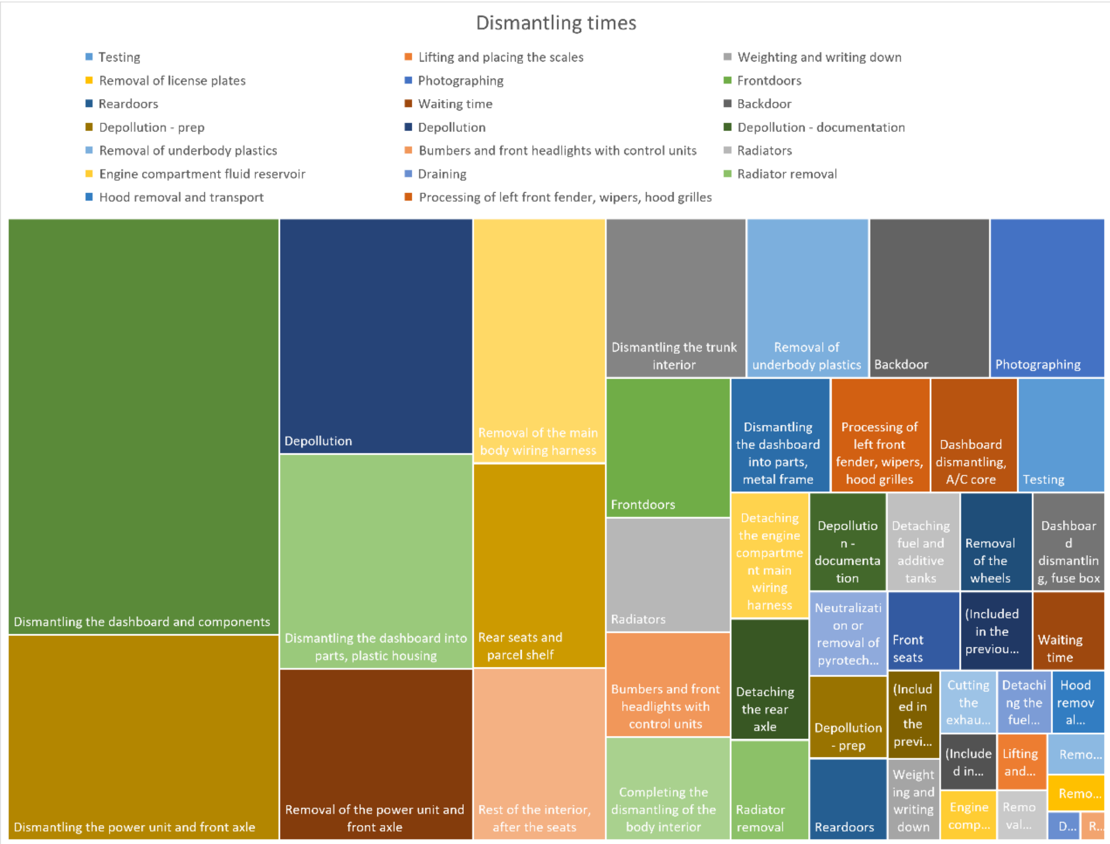


Figure 35. Relative contribution of work stages to total working time.

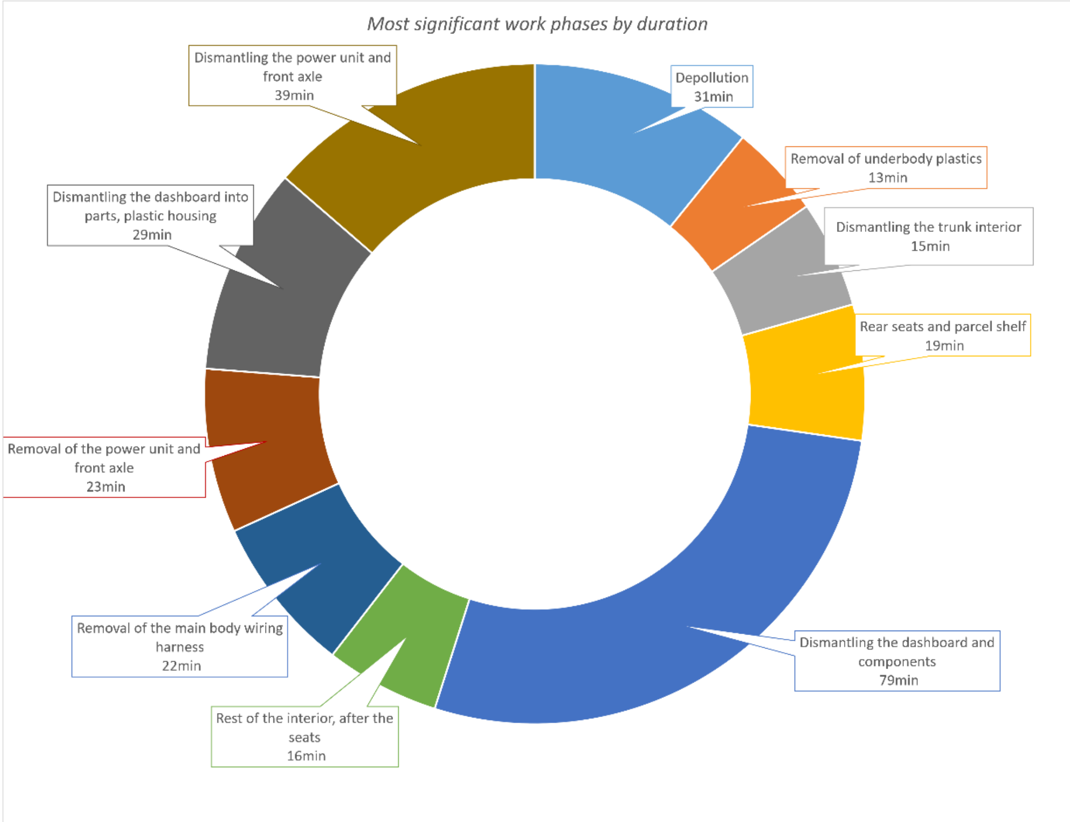


Figure 36. Illustrative overview of work stage durations.

Other work stages associated with significant time requirements included:

- vehicle depollution (fluid extraction and removal): approximately 40 minutes
- partial interior dismantling and seat removal: approximately 39 minutes
- removal of the powertrain and axles: approximately 39 minutes
- removal of exterior body plastics and radiator components: approximately 40 minutes.

The results suggest that dismantling in accordance with the proposed regulation is not characterised by a single bottleneck stage but rather by multiple medium-duration and interdependent operations whose combined effect substantially increases total processing time.

5.3 Material and Component Recovery

The dismantling demonstration enabled recovery of a significant quantity of materials and components prior to transferring the body shell for shredding. The initial mass of the vehicle was 1,495 kg, whereas the final mass of the body shell transferred for shredding was 380 kg. This indicates that a total of 1,115 kg of materials and components was removed from the vehicle. These results suggest that dismantling in accordance with the proposed regulation directs a substantially greater share of vehicle mass towards separate recovery and subsequent processing than current dismantling practices based on minimum requirements.

Particularly notable observations related to the recovery of critical raw materials and other economically valuable material streams. For example, 13 kg of copper wiring was recovered from the vehicle, primarily through removal of the main wiring harnesses. In addition, several components were directed to reuse, supporting one of the regulation’s central objectives: improving circularity and extending the value retention of vehicle components and materials.

5.4 Documentation and Further Processing of Components

Assessment, documentation and further processing of removed parts and components in accordance with the proposed regulation emerged as a distinct and resource-intensive stage following dismantling. Cleaning of removed components required approximately 39 minutes, photography approximately 26 minutes, and packaging together with preparation for sale approximately 50 minutes. In total, documentation and post-processing activities required 112 minutes. Although this duration is not typically included in conventional estimates of dismantling work, it may become necessary to meet the requirements set out in Articles 30 and 31 of the proposed regulation.

The observations indicate that documentation obligations may significantly increase overall resource requirements and underline the potential importance of digital tools, automated information management and improved process integration in future operating models.

5.5 Summary of Key Findings

The results of the dismantling demonstration suggest that processing end-of-life vehicles in accordance with the proposed Regulation on End-of-Life Vehicles is technically feasible within existing dismantling environments. However, implementation is likely to require substantially more time, planning and documentation than current operating practices. At the same time, regulation-compliant dismantling appears to enable more extensive recovery of materials and components while increasing overall labour requirements and emphasising the importance of process development, production-line operating models and digitalisation in improving operational efficiency.

6 Future Research Needs

The proposed Regulation on End-of-Life Vehicles introduces new requirements across the entire vehicle life cycle, extending from vehicle design and manufacturing to the recovery and further utilisation of materials from end-of-life vehicles. This study focused specifically on mandatory dismantling requirements under Annex 7 Part C. To support a successful transition towards circular economy operating models, the automotive sector will require additional research, practical experimentation and generation of operational knowledge.

6.1 Dismantling Demonstrations and Process Development

The results of this study indicate that dismantling demonstrations can be conducted within operational dismantling facilities without materially disrupting normal business activities. Future demonstrations should be carried out using a broader range of vehicle types and technical configurations. Vehicle make and model, together with the experience and expertise of dismantling personnel, appear to influence both the efficiency and practical implementation of the dismantling process. Turku University of Applied Sciences is currently preparing a second dismantling demonstration in collaboration with industry partners, focusing on dismantling processes for electric vehicles.

Additional research into the economic viability of dismantling operations could support development of the wider vehicle dismantling ecosystem. Further research is needed to develop clear assessment criteria for determining when the labour time and costs associated with dismantling and component refurbishment genuinely exceed the economic value generated through recovery. Establishing such criteria could also support consistent interpretation and application of exemption provisions.

Obtaining vehicle-specific dismantling instructions in advance would likely improve the efficiency of the dismantling process. During the demonstration, it was observed that a considerable amount of time was spent determining appropriate dismantling methods and identifying suitable tools. Comprehensive dismantling instructions or structured dismantling guides could provide practical support in such situations.

Windscreen removal is challenging because the glass is typically bonded to the body using strong adhesives and removing it intact is not straightforward. Breaking the glass is a common method; however, it causes significant dust generation and poses an occupational safety risk. One possible direction for future research could be softening the adhesive joint, for example by using induction heating, which could enable a more controlled and cleaner removal process.

The monitoring and traceability of parts, components and materials after vehicle dismantling should be considered in response to the requirements of evolving legislation.

6.2 Improving Dismantling Efficiency and Optimising Workstations

The dismantling demonstration highlighted the observation that removing components intact is the most time-consuming stage of the entire dismantling process. For example, removal of the front and rear doors took a total of almost 30 minutes during the demonstration. In minimum dismantling, these may be left in place or removed more quickly. As stated in earlier sections of this report, exemptions under Annex 7 Part G may potentially be applied to several parts required to be removed under the draft regulation. Improving dismantling methods through more straightforward removal approaches focused solely on material recovery is the most effective way to reduce working time and costs in situations where preserving components intact for reuse is not economically viable. Future dismantling tests should investigate and compare efficient dismantling approaches that take into account the exemptions under Annex 7 Part G. As indicated by the list of dismantled parts, the exemption conditions under Annex 7 Part G of the draft regulation may apply to up to one-third of the removed components.

During dismantling, a clear need was identified to improve workstation organisation and tool management. To maximise efficiency, all necessary tools should be ergonomically arranged and easily and rapidly accessible. In addition, improving the availability and visibility of dismantling instructions directly during execution of the work may significantly reduce delays in the dismantling process.

Since development of comprehensive guidance systems takes time, it would be beneficial to investigate experimentally the most natural way to present work instructions and identify components for the dismantling operator. Potential solutions include mobile devices, displays located at workstations and possibly augmented reality technologies.

However, differences in dismantler experience levels should be taken into account when developing dismantling instructions and workstations. In addition, there are significant differences in structures and dismantling methods between vehicle manufacturers, which places its own requirements on process flexibility and guidance systems.

6.3 Automation and Machine Vision

One factor influencing vehicle dismantling is the demanding manual nature of the work. Development of semi-automated or automated processes for dismantling could improve cost efficiency and reduce ergonomic risks for workers. Automation does not necessarily need to control physical equipment directly but may also be used for information transfer, data processing and generation of new information.

For example, a Manufacturing Execution System (MES) could be utilised in vehicle dismantling by producing digital, real-time work instructions that adapt to the vehicle model and condition and guide the operator step by step. In addition, the system enables collection of process data directly from work stages (e.g. removed parts, processing times and deviations), improving traceability and process optimisation. MES may also support material flow management, quality assurance and operational planning by integrating dismantling data with inventory, recycling and sales requirements.

Machine vision itself provides the capability to identify objects and measure geometry, but as a research field it does not in itself generate significant new knowledge. In vehicle dismantling, research value could arise from further processing and utilisation of collected data. The key issue is how information is transformed into decisions, for example through automatic selection of dismantling strategies, assessment of component condition or real-time process control. Combining data with other systems (e.g. MES) and applying learning models could allow the process to continuously adapt to varying vehicles and improve efficiency over time.

The use of industrial robotics in vehicle dismantling is challenging primarily because of the initial conditions: dismantled vehicles vary in model, age and level of damage, which complicates the design of tools and grippers and requires advanced sensing and adaptive processes. In addition, uncertainty relating to structures and joining methods (e.g. welds, fasteners and adhesives) complicates reliable automation. The cost-effectiveness of investments may remain limited if throughput is inconsistent or volumes are low. In practice, robotics can nevertheless be utilised together with machine vision, 3D scanning and other sensing technologies depending on the process.

Industrial robotics can also be applied through semi-automation, where the robot performs heavy or repetitive stages, but the operator can interrupt and manually guide movement in variable dismantling situations. Such a situation could involve stopping the robot close to the dismantled vehicle and manually assisting or guiding the robot to the target surface. Future research could therefore focus on safe implementation of semi-automation while taking into account risks and uncertainties arising from variable loads during component handling.

6.4 Improving Work Ergonomics

Future studies should investigate how automation and production-line approaches could help prevent occupational diseases and repetitive strain injuries resulting from poor work ergonomics. Where possible, workstations should utilise lifting aids for moving heavy parts and develop new tools to facilitate dismantling work. One significant factor affecting ergonomics is current lifting technology. Dismantling is mainly carried out using traditional vehicle lifts, and there are currently only limited methods for changing vehicle position, such as tilting the vehicle onto its side to improve access to underbody structures.

Working ergonomics inside the vehicle could be improved through structural pre-processing measures. For example, removing glass at an early stage of dismantling, disconnecting roof wiring and opening or removing the entire roof would significantly improve visibility and working space for dismantlers. This would significantly facilitate the removal and transfer of large and difficult components, such as the dashboard, out of the vehicle.

Partial removal or opening of the roof would not only facilitate manual work but would also create conditions for the use of robotics by providing industrial robot grippers with unobstructed access to the vehicle interior. As stated earlier, the use of robotics is challenging due to the variability of the vehicle fleet and is likely to be most efficient on production lines processing large numbers of vehicles of the same model.

6.5 Responding to Changing Legislation

The Regulation on End-of-Life Vehicles sets minimum requirements for recycling of plastics and glass, and in the future minimum shares will also be established for steel, aluminium, magnesium and rare earth elements. Manufacturers will be required to demonstrate the share of recycled materials used in the production of new vehicles in relation to these materials. The regulation will also define calculation methods for each recycled material.

Future studies may investigate material recovery potential, source separation and recycling opportunities.

Analysis of the legislation related to the Regulation on End-of-Life Vehicles is still at an early stage, and no guidance for national interpretation has yet been published. Future research should examine the current legislative situation to ensure that the information produced reflects future changes as accurately as possible.

7 Conclusions

The Regulation on End-of-Life Vehicles and the new requirements introduced by it will affect the entire vehicle ecosystem, from manufacturing to end-of-life treatment. The European Union emphasises the need to develop the automotive industry towards greater self-sufficiency and a more circular economy. The new legislation will influence vehicle design and manufacturing in such a way that the dismantling process will become easier as increasing numbers of newly designed vehicles enter the market.

The latest version of the Regulation on End-of-Life Vehicles was published in English in February 2026. Translation into Finnish and analysis of its application to the Finnish market context are still ongoing. Compared with previous legislation, the new regulation is intended to be more easily applicable across the European Union regardless of Member State. At the time of this dismantling demonstration, analysis of the legislation and its practical adaptation to the vehicle industry value chain remain unclear.

At present, dismantling levels for end-of-life vehicles vary significantly between operators, for example according to company requirements and vehicle condition. With the new draft regulation, practices will become more harmonised, as all treatment facilities will in future be required to carry out at least the minimum level of dismantling defined by the regulation, particularly with regard to depollution and recovery of certain critical raw materials. Annex 7 Part C of the Regulation on End-of-Life Vehicles lists the mandatory parts and components that must be removed from end-of-life vehicles in the future. The demonstration showed that removal of these parts is possible but considerably more time-consuming than current practices.

In order to make the vehicle dismantling process more efficient and economically viable, the dismantling process should be developed towards semi-automated, fully automated and production-line-based solutions. Once all operators are required to perform certain measures, these requirements can be utilised in the development of production lines or automated solutions for dismantling operations. Under the new regulation, all operators will be required to carry out extensive documentation, which will require significant working time; in the future, this may be facilitated through the use of artificial intelligence in data processing.

The dismantling test generated valuable and concrete time-related data that may be utilised more broadly across the sector in the future. The material generated from the results will be utilised by Turku University of Applied Sciences' Vehicle Dismantling Line 2.0 project in the conceptual design of a vehicle dismantling line simulation. The recorded work stage timings will enable accurate modelling in future of the time and resources required for processing in accordance with the new regulation.

Following completion of the demonstration, the working group convened to discuss the successes of the trial and identify areas for future development. For the dismantling demonstration, the working group carried out extensive planning aimed at understanding all stages of the demonstration in advance. The working group considered this planning to be a significant cornerstone of the successful execution and implementation of the demonstration.

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Part No.	Part Name	Regulation-Compliant Dismantling
1	ABS Hydraulic Unit	Annex 7 Part C
2	Airbag Clock Spring	Annex 7 Part B
3	Headlight, Left	Annex 7 Part C
4	Front Lower Control Arm, Right	No
5	Front Lower Control Arm, Left	No
6	Bonnet Lock	No
7	Front subframe / front axle assembly	No
8	Glove compartment, complete	No and yes (plastic recycling)
9	Air-conditioning compressor	Annex 7 Part B and Part C
10	Front shock absorber	No
11	Front shock absorber	No
12	Radiator fan assembly	Annex 7 Part C
13	Anti-roll bar link	No
14	Switch, emergency stop	No unless related to the eCall system
15	Centre console, floor-mounted	No and yes (plastic recycling)
16	Dashboard	Assembly: yes; after removal of parts: no
17	Starter motor, petrol	Annex 7 Part C
18	Alternator	Annex 7 Part C
19	Front wing, left	No and yes (plastic recycling)
20	Lock / tailgate lock	No
21	Temperature controls	No and yes if part of a larger assembly
22	Instrument cluster, complete	Annex 7 Part C
23	Petrol engine	Annex 7 Part C
24	Steering wheel	Assembly: yes; after removal of parts: no (Annex 7 Part B)
25	Steering wheel airbag	Annex 7 Part B
26	Electric steering gear	Yes and no; control units / electronic components – Annex 7 Part C
27	Headlight control unit	Annex 7 Part C
28	Headlight control unit	Annex 7 Part C
29	Headlight control unit	Annex 7 Part C
30	Headlight control unit	Annex 7 Part C
31	Engine control unit	Annex 7 Part C
32	Front door, right	Assembly: yes; after removal of parts: no
33	Front door, left	Assembly: yes; after removal of parts: no
34	Rear door, right	Assembly: yes; after removal of parts: no
35	Rear door, left	Assembly: yes; after removal of parts: no
36	Windscreen and headlight washer reservoir	Fluids, Annex 7 Part B
37	Accelerator pedal	No
38	Dismantling vehicle	Body shell

39	Rear bumper	Annex 7 Part C
40	Bumper insert / grille	No and yes (plastic recycling)
41	Rear bumper mounting brackets	No
42	Rear bumper mounting brackets	No
43	Rear bumper mounting brackets	No
44	Rear bumper beam	Annex 7 Part C
45	Radio	Annex 7 Part C
46	Radio / CD control panel	Annex 7 Part C
47	Gear lever console trim	No and yes (plastic recycling)
48	Interior rear-view mirror	No
49	Side skirt, right	No
50	Side skirt, left	No
51	Electric door mirror, right	Annex 7 Part C
52	Electric door mirror, left	Annex 7 Part C
53	Fuse box / main electrical unit	Annex 7 Part C
54	Fog lights / auxiliary lights	Annex 7 Part C
55	Rear axle beam	No
56	Powered tailgate unit	Annex 7 Part C
57	Powered tailgate unit	Annex 7 Part C
58	Powered tailgate unit	Annex 7 Part C
59	Tailgate, estate	No
60	Rear window wiper motor	Annex 7 Part C
61	Rear light, right	Annex 7 Part C
62	Tailgate rear light, right	Annex 7 Part C
63	Tailgate rear light, left	Annex 7 Part C
64	Rear light, left	Annex 7 Part C
65	Luggage compartment cover	No
66	Adaptive speed sensor	Annex 7 Part C
67	Front seat belt, right	Annex 7 Part B
68	Front seat belt, left	Annex 7 Part B
69	Rear seat belt, right	Annex 7 Part B
70	Rear seat belt, left	Annex 7 Part B
71	Windscreen wiper arm, left	No
72	Windscreen wiper motor	Annex 7 Part C
73	Gear selector	No
74	Automatic transmission	Annex 7 Part C