CMF Circularity AI: Transforming Vehicle Design with Customer Insights

Public report
Project within: FFI Cirkularitet
Author: Kostas Stylidis, PhD
Date: 2025-12-23

FFI Fordonsstrategisk Forskning och Innovation

Content

FFI in short

FFI, Strategic Vehicle Research and Innovation, is a joint program between the state and the automotive industry running since 2009. FFI promotes and finances research and innovation to sustainable road transport.

For more information: www.ffisweden.se

1. Summary

The CMF Circularity AI project developed new approaches to embed circular economy principles into automotive design without sacrificing customer expectations for quality. By focusing on Color, Material, and Finish (CMF) decisions, the project leveraged AI-driven support and customer insights to help designers choose sustainable materials that meet both environmental goals and premium design standards. A multidisciplinary team from industry and academia collaborated over 12 months to create a first-of-its-kind CMF Circularity Framework, build a material-attribute database, and prototype an AI assistant that serves as decision support for sustainability and circularity criteria trade-off. Through extensive user studies, the project also identified key challenges (e.g. organizational barriers and trust in AI) and developed guidelines to ensure the AI solutions are user-friendly for designers. The project's outcomes show strong potential to reduce the material carbon footprint and accelerate the adoption of sustainable materials in vehicles. Notably, the work received industry recognition by reaching the finals of a Dagens Industri Tech Excellence Award in the category "Årets hållbara brobyggare", underscoring its relevance. In summary, CMF Circularity AI demonstrates how data-driven design innovation can bridge the gap between circular materials and customer acceptance, contributing to a more sustainable and competitive automotive industry.

2. Sammanfattning på svenska

Projektet CMF Circularity AI har undersökt hur cirkulär ekonomi kan integreras i fordonsdesign genom beslut om färg, material och finish (CMF), utan att kompromissa med upplevd kvalitet, estetik eller kundacceptans. Projektet genomfördes som en förstudie inom FFI Cirkularitet och kombinerade kvalitativa studier, ramverksutveckling och prototypbaserad AI-utveckling. Utgångspunkten var att många hållbara material upplevs som sämre än traditionella alternativ, samtidigt som CMF-beslut ofta tas sent i utvecklingsprocessen och med begränsat beslutsstöd. Projektet adresserade detta genom att utveckla ett CMF Circularity Framework som strukturerar sambandet mellan cirkularitetsprinciper, materialegenskaper och upplevd kvalitet. Ramverket bygger på etablerade cirkulära strategier och prioriterar designbeslut med hög påverkan tidigt i utvecklingen.
För att förstå nuvarande arbetssätt och behov genomfördes djupintervjuer med CMF-designers och tekniska roller inom fordonsindustrin. Analysen visade tydliga hinder för cirkularitet, såsom kunskapsluckor kring nya material, organisatoriska målkonflikter och osäkerhet kring kundacceptans. Samtidigt uttryckte användarna ett tydligt behov av AI-baserat beslutsstöd som är transparent, förklarbart och integrerat i befintliga arbetsflöden.
Projektet resulterade även i en CMF Circularity AI Agent-prototyp, baserad på en kunskapsgraf och retrieval-augmented generation, som kan analysera materialval utifrån både cirkularitet och upplevd kvalitet. Prototypen har testats i interna fallstudier och är

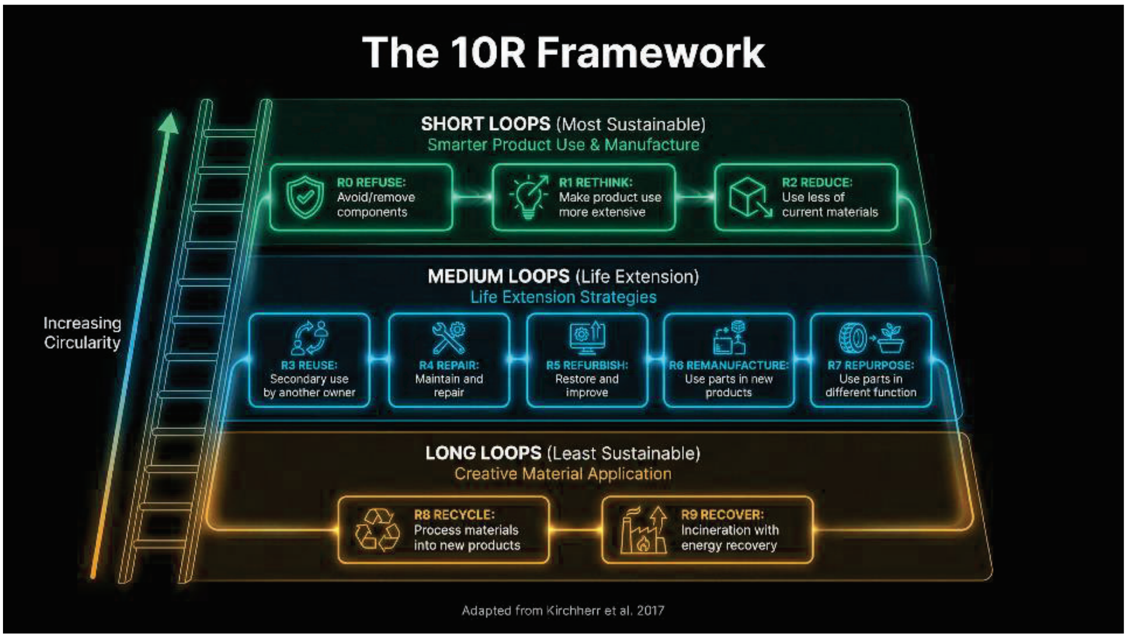
tillgänglig via en publik projektsida. Vidare har projektet genererat nya designriktlinjer för användarcentrerad AI, dokumenterade i en publicerad masteruppsats. Sammanfattningsvis visar projektet att AI-baserat beslutsstöd kan göra cirkularitet operativ i CMF-design och minska motsättningen mellan hållbarhet och premiumupplevelse. Resultaten utgör en stabil grund för fortsatt industriell validering i fullskalig uppföljningsstudie och bidrar till FFI:s mål om hållbar mobilitet, cirkulär ekonomi och designinnovation.

3. Background

The automotive industry is under intense pressure to reduce its environmental impact while still delivering products that meet consumer expectations for quality. A major challenge lies in incorporating sustainable materials into vehicle design without compromising perceived quality, durability, or aesthetics. Automakers today have access to eco-friendly materials (such as bioplastics, natural fibers, and recycled composites), but these alternatives are often perceived as lower-quality than traditional materials like leather or virgin plastics. As a result, design teams face difficult trade-offs: using conventional materials can maintain a high-quality feel but contributes to environmental harm, whereas greener materials support sustainability yet risk being seen as “cheap” or less durable. This tension has slowed the adoption of sustainable options in automotive interiors and exteriors.

Furthermore, current CMF design processes are slow and resource-intensive, requiring many iterations and physical prototypes to balance style, performance, cost, and sustainability. There is often a mismatch between what sustainable materials offer and what customers expect in terms of premium look and feel. For example, a recyclable fabric might be better for the planet, but if customers perceive it as less comfortable or upscale, manufacturers hesitate to use it. Meanwhile, sustainability goals (like reducing carbon footprint or increasing recycled content) are becoming more stringent, driven by regulations and corporate commitments to climate targets. In practice, however, design teams lack data-driven tools to quantify the impact of material choices or to predict customer acceptance of those choices in real time. This leads to incremental changes and lengthy design cycles, rather than the rapid transformation needed for climate goals.

In this project we adapted the **10R Framework** (Kirchherr, Reike, & Hekkert, 2017) which gives us a clear hierarchy for implementing circular economy strategies. We focused our efforts on the top of this ladder because the shorter the loop, the more sustainable and circular the strategy. The most impactful strategies are the Short Loops – Refuse, Rethink and Reduce because they eliminate the need for new material extraction in the first place. These are primarily design phase decisions. Moving down, the Medium Loops like Repair and Remanufacture focus on extending a product's life through maintenance and restoration. These strategies keep products in use longer and delay the need for recycling. Finally, the Long Loops like Recycle and Recover are our last resort. While necessary, they require significant energy and material processing, making them the least circular option. We must prioritize the R's at the top to truly shift from a linear to a circular model.



Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, conservation and recycling, 127, 221-232.

In summary, the project's background is a landscape in which automotive CMF decisions need to be reimagined. There is a critical need for innovative approaches that align sustainable material selection with customer-defined notions of quality. By doing so, the industry can avoid the false dichotomy of “eco vs. premium” and move toward vehicles that are both environmentally responsible and appealing to consumers. This project was performed to address that need, leveraging advances in AI and a human-centered design approach to make sustainable choices easier and more informed.

4. Purpose, research questions and method

The purpose of the CMF Circularity AI project was to investigate the ability to transform vehicle design processes by aligning customer preferences with sustainable design principles. In essence, the project set out to bridge the gap between circular materials and customer acceptance using advanced AI techniques. By developing a framework specialized for Color, Material, and Finish, creation of a Knowledge Graph representing this framework in a form usable as data input for Agentic AI, the project aimed to help designers make informed decisions that enhance circularity (recyclability, low carbon footprint, etc.) while still meeting or exceeding consumer expectations for quality and aesthetics. The core aim was to produce design recommendations that satisfy environmental objectives and what drivers see, touch, and feel in a vehicle. This aligns closely with the goals of the FFI Circularity program – reducing environmental impact across the vehicle life cycle – while also introducing a novel approach (AI and customer data) to achieve these goals.

Two main research questions guided this feasibility study:

- **RQ1**: How do automotive CMF designers currently integrate – or struggle to integrate – circular economy principles in their design decisions?
- **RQ2**: What do they expect or require from emerging AI tools to better support CMF circularity in their design practice?

The project used a qualitative, case study design, bounded by the CMF Circularity AI project context in automotive CMF design. Data were collected through in-depth, semi-structured interviews with professional CMF designers, studio engineers and related roles at OEMs and a Tier-1 supplier. Participants were recruited purposively based on direct experience with CMF and sustainable materials. Each interview (≈60–90 minutes) followed a common guide covering CMF decision-making, circularity challenges, and expectations on AI tools. Interviews were recorded, transcribed using an offline ASR tool, anonymised, and handled in accordance with GDPR.
The transcripts were analysed using qualitative thematic analysis combined with case-study techniques such as pattern matching and explanation building. Two researchers independently open-coded the data, then iteratively refined codes into themes corresponding to RQ1 (current integration of circularity) and RQ2 (AI tool expectations). Themes were cross-checked against the raw data and discussed within the team to strengthen reliability.
The information was then synthesized into the CMF Circularity Framework, and a series of workshops was performed to validate the framework with industrial partners.
Subsequently, all information, relationships, and dependencies were represented as a Knowledge Graph. We used Neo4j as a graph database management system and GPT-4o Nano as a base model to enable conversations. The landing page and the frontend API application were built and deployed for public access as well (https://cmf.intendedfuture.ai/)

In summary, the project's purpose was to demonstrate a path toward data-informed, AI-assisted sustainable design that could be adopted broadly in the automotive industry.

5. Objective

The objective of the feasibility project was to develop and test an approach for selecting sustainable CMF materials that align with customer expectations for quality, appearance, and tactility. The project aimed to reduce environmental impact by enabling the use of eco-friendly materials without compromising perceived quality or premium design intent.
A further objective was to gain deeper insights into how customers perceive sustainable CMF options, in order to increase acceptance of eco-friendly materials in automotive

applications. By combining customer insights with structured CMF and circularity knowledge, the project sought to support designers in making more informed and confident material decisions early in the design process. Through the development of the CMF Circularity Framework and a CMF Circularity AI Agent, the project aimed to establish a new reference approach for sustainable automotive CMF design. This approach uses AI to integrate Color, Material, and Finish decisions with circular economy principles, while also considering inclusivity and diverse user perspectives, with the long-term goal of minimizing environmental impact across the vehicle life cycle.
The AI-driven material choices should significantly cut emissions relative to baseline materials. The ultimate goals of subsequent validation must be

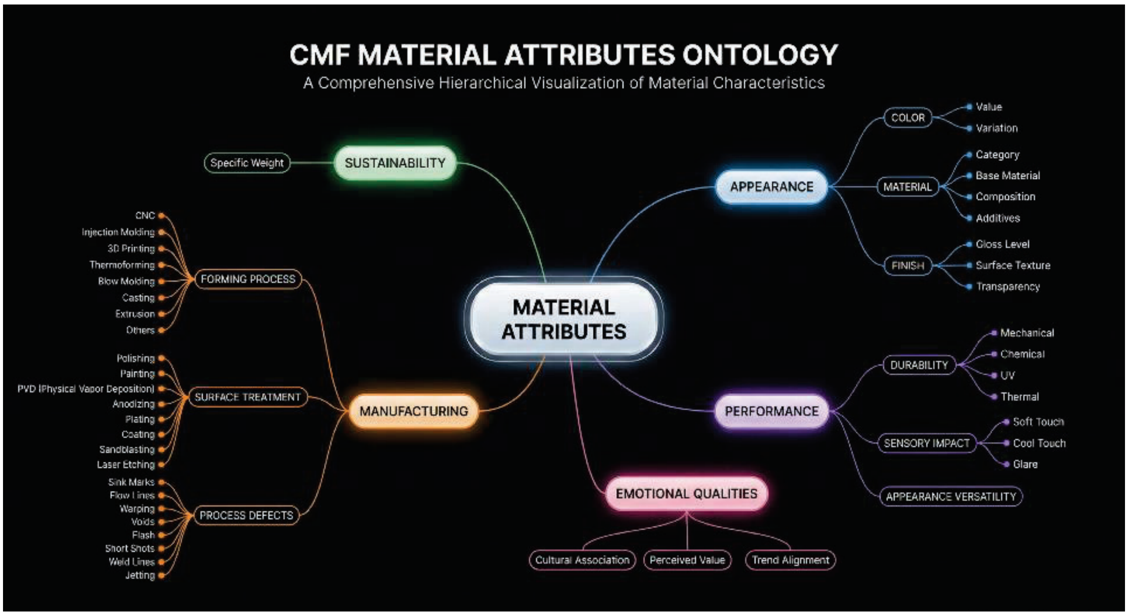
- Customer Acceptance: Ensure that at least 90% of customers in evaluations rate the AI-selected sustainable materials as equal to or superior in quality to traditional materials (based on attributes such as appearance, texture, and finish). This gauges the success of aligning eco-materials with premium feel.
- Efficiency Gain: Shorten the time-to-market by 30% for implementing new materials through AI-driven generative design. By reducing reliance on extensive physical prototyping and iterations, the project aimed to speed up the design process.
- Waste Reduction: Cut material waste by 20% during the design and prototyping phases using AI optimization. Smarter early-phase decisions would mean fewer discarded prototypes and more efficient use of materials.
- Circular Material Use: Increase the use of recyclable or renewable materials to at least 50% of the total material content in the vehicle components studied, thereby directly supporting circular economy practices.

These objectives provide clear benchmarks for what the pre-study needed to enable. During the project, we used the CMF AI Agent prototype in a series of internal test cases to benchmark its performance on typical CMF decisions, compare alternative material choices, and check how well its suggestions align with designer judgment and circularity criteria. In this way, we shorten time to market with an AI Decision Support system, the rest of the targets need to fully achieve the figures in production, but they demonstrate that the approach can be operationalised and that the goals are realistic. The pre-study has therefore mainly delivered the methods, data structures, and prototype tools needed to pursue these targets in real vehicle programs. Based on the promising preliminary results, the partners are preparing an application for a full-scale follow-up project where the CMF AI Agent will be validated in industrial pilots, with measured effects on carbon footprint, material waste, lead time, and customer acceptance.

6. Results and deliverables

Despite the limited timeframe, CMF Circularity AI delivered several important results that collectively demonstrate the feasibility and potential of AI-assisted circular design in the automotive context. The key outcomes include:

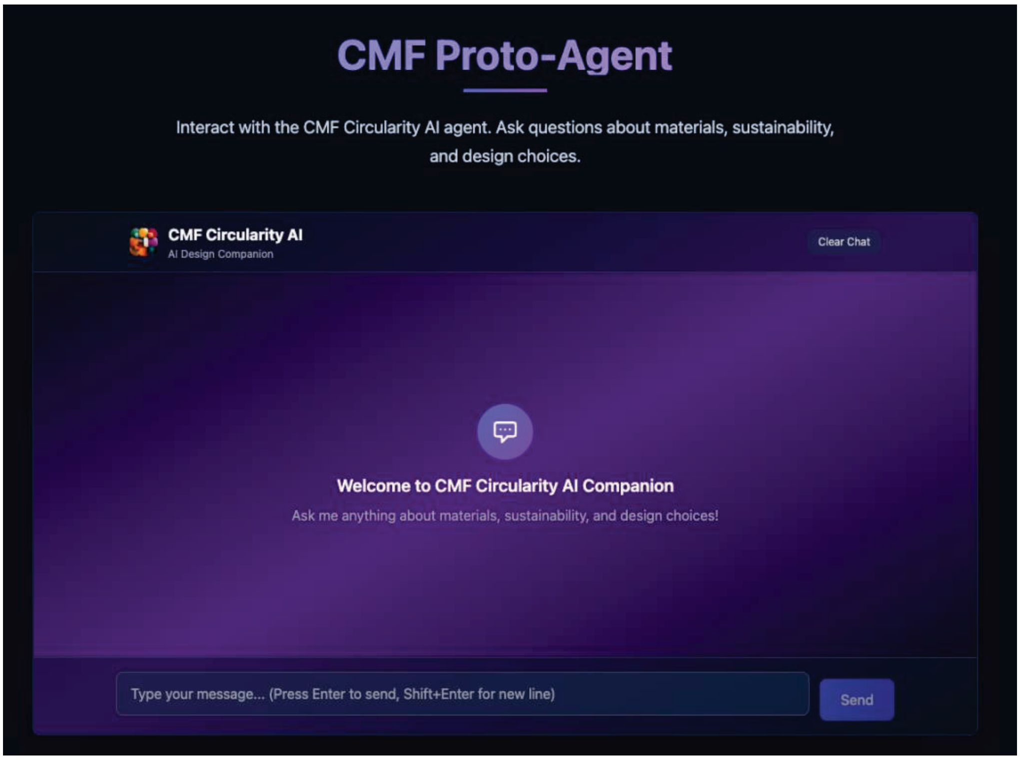
- **CMF Circularity Framework:** The project developed a comprehensive framework that integrates circular economy criteria into CMF design decisions. This framework serves as a conceptual model and checklist for designers and engineers. It links material attributes (CO_2 footprint, recyclability, renewable content) with design attributes in a structured way. By formalizing these connections, the framework allows project teams to spot trade-offs and synergies. It also aligns with standards and strategies (e.g., referencing ISO circularity indicators and the 9R strategies of reuse, recycle-adapted for automotive design decisions).



The framework document is one of the key deliverables from the project and has been shared among the partners.

- **Material Attribute Database:** Closely tied to the framework is the CMF material attribute database that was created. This is a working repository of data for dozens of materials commonly (or prospectively) used in vehicle interiors and exteriors. Each material entry includes technical data (mechanical properties, manufacturability constraints), environmental data (life-cycle assessment results like carbon footprint per kg, recyclability, presence of toxins or critical elements), and descriptive attributes (appearance, texture, supplier info). By compiling this, the project addressed a major gap: previously, designers had to consult disparate sources or guess about sustainability metrics. Now, there is a centralized database that an AI (or a human) can query to compare materials on an apples-to-apples basis. For instance, the database can show that Material A (a recycled polymer) has 40% lower CO_2 but slightly higher cost than Material B (virgin plastic), and note any differences in perceived quality (perhaps Material A has a matte finish versus glossy for B). During the project, data was collected from literature, suppliers, and partner inputs to populate the database. While not exhaustive, it proved sufficient to drive the AI demonstrator and can be expanded in future work. This deliverable is valuable on its own, as partners like CIT and the OEMs indicated they could continue to maintain and use it in their material selection processes.

- **CMF AI Demonstrator:** A highlight of the project is the functional CMF Circularity Agent prototype that was developed and showcased. This prototype is a proof-of-concept "CMF design assistant" – effectively a tool where a designer can ask questions or request recommendations, and the AI uses the project's knowledge base to respond. Technical stack: foundational Knowledge Graph system on Neo4J, conversation powered by ChatGPT 4o nano via API calls, designed graph visualizations for material relationships and sustainability metrics, implemented webhooks for real-time data flow.



The CMF Circularity AI demonstrator is publicly available at https://cmf.intendedfuture.ai/

Technically, it combines a knowledge graph of CMF Circularity data with a retrieval-augmented generation (RAG) approach, employing a language model to generate user-friendly answers. For example, a designer could query: "What's the most sustainable alternative to the current seat fabric that still feels soft to touch?” The AI will search the material database for options with lower environmental impact and cross-reference any data on feel (perhaps via a customer preference rating or a proxy like material softness rating). It might answer with: “Consider switching from Material X to Material Y – it’s 30% lower in CO_2 emissions and 100% recyclable. Material Y has a slightly different texture but was rated equally comfortable in our user survey. It also meets the durability requirements for seating.” The demonstrator was tested with a set of example queries like this, and it successfully provided context-specific suggestions along with explanations. While still a rudimentary tool, it illustrated the power of combining data-driven search with AI-generated insight. The interface was command-line or text-based for now, but it reflected how a future design assistant could operate. This result is significant because it moves beyond static guidelines – it shows an interactive solution that can augment human decision-making. The concept was well-received by partners, who noted that such an assistant could help junior designers learn from past data and help senior designers crunch complex trade-offs more quickly.

- **Insights from Practitioner Interviews:** The qualitative research component of the project yielded rich insights into current practices and barriers in adopting sustainable materials. Through ~6–8 in-depth interviews with CMF designers and product developers (from automotive manufacturers and suppliers), the project performed a content analysis to distill common themes. Key findings included: (a) Cultural and organizational misalignment – sustainability is often promoted at a high level but not fully integrated into day-to-day design decisions due to cost and time pressures, leading to a “last-minute” approach to material changes; (b) Knowledge gaps – designers reported not having reliable information on novel materials’ performance, which makes them stick to the “devil they know” (traditional materials) rather than risk unknown issues; (c) Perception challenges – there is a widespread concern that customers will not accept unfamiliar sustainable materials in a luxury context, creating a cautious mindset among decision-makers. These insights reinforced why the CMF Circularity AI approach is needed. For example, one recurring comment was that sustainable material adoption should become ‘hygiene’ (a given) rather than a special case – indicating support for tools that normalize considering those options. The interviews also highlighted that designers seek hard data and evidence to justify material decisions (to management or to themselves), which directly validated the project’s focus on providing quantitative metrics and AI-supported evidence. All interview transcripts were documented, and a summary of findings has been shared with the partners as a deliverable. This new knowledge helps shape how companies might manage change when introducing AI and sustainability into their design processes.

- **Design Guidelines for AI in Design (Master’s Thesis):** As a supplementary but very relevant result, the Master’s thesis work produced design guidelines for implementing user-centered AI tools in automotive design. These guidelines address both functional features and interaction design aspects needed to ensure an AI agent is adopted and trusted by designers. Examples of the guidelines are: "Ensure transparency in AI recommendations" (the AI should show why it suggests a material, e.g. by exposing key data comparisons); "Preserve designer autonomy" (the AI should suggest, not dictate, and allow the human to override or adjust inputs); "Integrate into existing workflows" (the tool should plug into software or processes designers already use, like CAD or material libraries, rather than adding extra burden); "Provide feedback and learning" (the AI should learn from user preferences over time and also educate users about new materials or concepts). The thesis also delivered a high-fidelity UI prototype demonstrating how an AI assistant might look: for instance, a sidebar in the CAD software where the AI can be chatted with, showing material options with ratings and a "confidence" indicator, etc. While this prototype was not an official deliverable of the FFI project, it is an outcome that the project enabled and it adds value to the overall results. It gives a clear direction on how to design the user interface for the AI assistant so that it will be accepted by its intended users (automotive designers, engineers, decision-makers). These guidelines will directly feed into future development; they have been documented and will serve as requirements in the next phase when building a full-fledged system.

- **Gender and Inclusion Perspective:** An important result to note (though qualitative) is the integration of a gender equality perspective into the project's outcomes. By ensuring equal gender representation in research and design of the AI, the project helped surface considerations that might otherwise be overlooked. For example, during the customer insight activities, the team considered whether different demographic groups (men, women, etc.) might have different tactile preferences or trust levels regarding certain materials (e.g., some studies suggest differences in how males and females perceive certain textures or colors in car interiors). While our scale was small, the inclusive approach means the resulting framework and tool are set up in a way that assumes diversity in end-users. The CMF Circularity AI is envisioned to allow filtering or checking recommendations against different user profiles (in the future, it could ensure that material choices are validated for both a broad male and female customer base in terms of comfort and acceptance). By building this thinking in from the start, the project contributes to FFI's goals on social sustainability and ensures that innovations do not inadvertently reinforce biases.

Collectively, these deliverables, the CMF framework, database, CMF AI demonstrator, research insights, and design guidelines, address the project objectives and provide a multi-faceted result. Technologically, we've shown that an Agentic AI can handle complex multi-criteria decisions (sustainability + quality). From a process standpoint, we've documented methods to incorporate circular metrics into design. And in terms of human factors, we've clarified what end-users (designers, customers) need in order to embrace these new solutions. Importantly, the results also contribute to the broader goals of FFI-Circularity Program. The reduction in carbon footprint and waste, if realized at scale, directly supports more sustainable mobility by cutting emissions in vehicle manufacturing. The framework and database lay the groundwork for a circular economy approach in design, potentially increasing the use of recycled and renewable materials across the industry. The innovative AI approach pushes the envelope in design innovation, introducing advanced digital tools to a field (CMF design) that traditionally relies on physical samples and intuition. And the close collaboration among partners exemplifies industry collaboration - knowledge was exchanged fluidly, and each party's strengths were leveraged to achieve these results.

7. Dissemination and publications

7.1 Dissemination

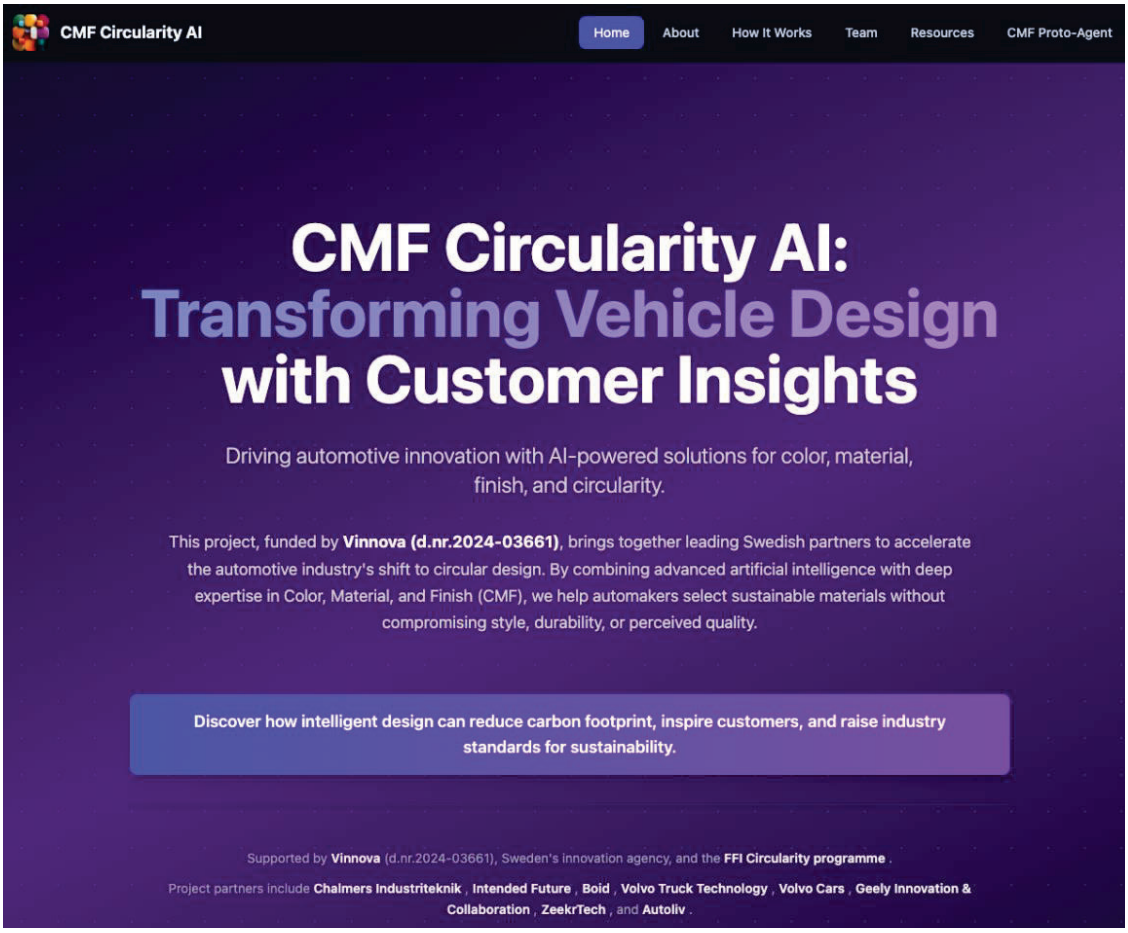
How are the project results planned to be used and disseminated?	Mark with X	Comment
Increase knowledge in the field	X	The project has generated new knowledge on CMF circularity, customer perception of sustainable materials, and the role of Agentic AI in CMF decision-making.
Be passed on to other advanced technological development projects	X	The results form the foundation for a planned full-scale follow-up project, where the CMF Circularity AI Agent will be further developed and validated in industrial pilot cases.
Be passed on to product development projects	X	The CMF Circularity Framework and CMF Circularity Agent are intended to be applied in future vehicle development projects, supporting early-phase CMF decisions related to material selection, circularity, and perceived quality. The pre-study demonstrates how the approach can be integrated into existing design workflows.
Introduced on the market		The project is a pre-study and does not include direct market introduction. However, the results are intended to enable future commercial offerings of AI-based CMF decision-support tools following further validation and development.
Used in investigations / regulatory / licensing / political decisions		The results are not directly aimed at regulatory or political decision-making, but the framework aligns with circular economy principles and sustainability regulations, and may indirectly support compliance discussions in future projects.

To support dissemination and early adoption, a public project landing page has been created, including a working prototype of the CMF Circularity AI Agent, accessible at:

https://cmf.intendedfuture.ai/

This platform allows stakeholders to explore the framework and AI concepts in practice, lowering the barrier for engagement and further development.

In addition, the project connects to ongoing internal development at Intended Future related to AI agents CMF and Circularity decision support.



7.2 Publications

- **A Master's thesis was completed:**

  Andersson, V., & Siljeklint, M. (2025). Guidelines for Designing User-Centered AI Agents for the Automotive Industry, Under the Hood of Creating an Interface to Support Perceived Quality Evaluation in Automotive Design. https://odr.chalmers.se/items/f6165c4c-4670-4b76-bf12-fc511cdbb9b3

  The thesis documents qualitative research with automotive CMF and design quality professionals and presents guidelines for designing user-centered AI agents in automotive design contexts.

- In addition, **a practice-oriented guide** was produced by the design agency BOID:

Hayman, J. (2025). Circularity and CMF Design: User Needs in the Age of AI.
The guide summarizes practitioner insights and user needs related to CMF circularity and AI-supported design decision-making.

- **A research paper** based on the project has been submitted for peer-reviewed publication:

  Stylidis, K. et al. (submitted). What Designers Need from Agentic AI: Case of Circularity and CMF Design. Submitted to Design Conference 2026 – Procedia in Design Science.

  The paper reports findings from the project and discusses implications for the design of agentic AI systems supporting circular CMF design.

8. Conclusions and future research

The CMF Circularity AI project set out to tackle a pressing dual challenge: (i) making vehicles more sustainable while keeping customers delighted, and (ii) it has delivered promising evidence that AI-driven, customer-informed design can be a key part of the solution.
Through this pre-study, we demonstrated that it is feasible to incorporate circularity considerations into the creative, fast-paced world of automotive design without slowing it down or lowering the quality. The project's tangible outputs: the CMF Circularity Framework, the materials database, and the Agentic AI prototype, are a proof of concept. Designers can be empowered by data and AI to make better decisions for the planet and for users. We showed that an AI assistant can juggle multiple objectives (CO_2, recyclability, cost, aesthetics) and deliver recommendations that a human might not have considered or been able to obtain as quickly. We also confirmed that designers and stakeholders are receptive to such tools, provided the tools are built with their needs in mind (transparency, usability, etc.). The initial objectives set at the start have been addressed in principle: for example, the prototype recommendations indicate pathways to achieve the 25% material carbon reduction (in one test scenario, the AI's suggested material swap yielded an estimated 30% CO_2 reduction with negligible perceived quality loss. While exact metrics like "90% acceptance" or "20% waste reduction" will need full-scale implementation to measure, the project has laid the groundwork to attain those targets.
A significant conclusion is that customer insights can be successfully linked to engineering and sustainability data via Agentic AI. This interdisciplinary linkage between what customers feel and what they experience is where the innovation truly lies. We found that by bringing customer preference data into the loop, we addressed the often-cited risk "will people like the sustainable option?" head-on. The result is a more confident design process: teams can justify sustainable choices not only with environmental rationale but also with predicted customer satisfaction data. This approach can dramatically increase companies'

willingness to pursue bold material changes, knowing they are less likely to backfire in the market.

Contributions to FFI Goals: The project contributes to sustainable mobility by targeting one of the upstream sources of environmental impact: materials and design. If the methods pioneered here are widely adopted, future vehicles could incorporate much higher percentages of recycled or low-carbon materials, directly reducing emissions from production and eventually enabling greater recyclability at end-of-life. This complements other FFI initiatives focused on electrification and efficiency by attacking the problem from a design angle. In the context of the circular economy, CMF Circularity AI provides a practical toolkit to implement circular principles (such as using secondary materials and designing for reuse) at the design stage. It operationalizes circular economy thinking for design teams, which is a step change from treating circularity as a vague goal – we now have a template for action.
When it comes to design innovation, the use of AI in the aesthetic and materials selection domain is quite novel. The project has pushed the envelope of what design tools can do; traditionally, perceived quality and material selection have been artisanal processes that rely on designers' experience. Introducing Agentic AI here (and showing it can work) is an innovation that can make design processes more evidence-based, efficient, and inclusive. It does not replace the designer's intuition or creativity but augments it with computational power and breadth of data. This aligns with FFI's aim to keep Sweden's automotive industry at the cutting edge of technology.

Regarding industry collaboration, this project is a success story in how multiple stakeholders can jointly create value. This collaboration has not only produced the immediate outcomes but also built a network and common understanding that will outlast the project – an intangible yet critical contribution to the innovation ecosystem.

Challenges and Lessons Learned: The project was not without challenges, and these yielded lessons for the future. One challenge was data: assembling reliable and comparable data for materials proved time-consuming. We learned the importance of standardizing how data is reported (for example, ensuring CO_2 footprints are measured under the same scope and assumptions). We also faced the classic issue of change management – getting designers to trust an AI. By involving them early (through interviews and feedback sessions), we mitigated much of this resistance, highlighting a key lesson: co-development with end-users is essential for AI tools in creative domains. Another lesson is that one year is a short time to fully validate customer acceptance; while we incorporated customer voices qualitatively, the next step is to do targeted user testing (showing samples to customers and getting quantitative feedback on preferences, which can then loop back into refining the AI's predictive models). We also recognized that implementing this in a live project environment might require integration with companies' existing PLM (Product Lifecycle Management) systems and processes, which means the technology solution must be made enterprise-friendly in subsequent steps.
Future Outlook and Next Steps: The conclusion of this pre-study is really a beginning. The encouraging results have paved the way for a larger, scaled project. Concretely, the

next steps will include: expanding the materials database to cover hundreds of materials (with real data from suppliers and LCA databases), implementing the Agentic AI as a user-friendly software plugin used by design teams at Volvo Cars, Volvo Trucks, and Autoliv, and rigorously measuring the impact in live design projects. We will also incorporate more advanced features, such as goal-driven optimization (the Agent not just answering questions but actively proposing design configurations that meet set circularity goals. Another important future aspect is explainability and trust. We foresee that establishing trust will also involve a period of the AI working as a "co-pilot" with humans closely monitoring, until it proves its reliability, as echoed by our interviewees who said they would gradually trust AI after consistent performance.
From an inclusion standpoint, future work will continue the gender-balanced involvement and may begin to explore if there are any gender-specific insights in sustainable material preferences that the AI should account for (a research question that emerged but couldn't be fully explored yet).

Zooming out, the long-term vision enabled by CMF Circularity AI is one where automotive companies have, at their fingertips, a smart system that ensures every design decision moves them closer to sustainability targets, without losing sight of customer delight. Designs of future car interiors might have high content of recycled or bio-based materials, but a customer entering the vehicle would only notice how beautiful and comfortable it is – unaware (happily so) that an AI helped the design team choose those materials because they were the best for both the user and the environment. In other words, sustainable design will become seamless and inherent.
Finally, the CMF Circularity AI project has successfully demonstrated a new paradigm for vehicle design. It showed that circularity and customer-centricity can be synergistic when guided by intelligent tools. The project outcomes contribute to Sweden's and FFI's broader goals by pointing to a future of mobility that is sustainable by design. There is a clear path to expand and implement these results on a larger scale, and doing so could help the automotive industry make significant moves toward reducing its environmental footprint. Perhaps equally important, this project has showcased the value of combining expertise across fields – engineering, design, and artificial intelligence, to address complex problems. The team is optimistic and committed to carrying this work ahead, ensuring that the momentum gained translates into real-world changes in how cars are designed and built. The journey to transform vehicle design with customer insights and AI has only begun, but this project has proven that we are on the right track towards vehicles that are both circular and irresistible to customers, truly a win-win for society and industry.

9. Participating parties and contact persons

The project was carried out as a collaborative pre-study with contributions from a startup, a research institute, design consultants, and automotive industry partners. The team composition included Intended Future (Agentic AI and perceived quality experts), Stiftelsen Chalmers Industriteknik – CIT (sustainability and circularity researchers, AI experts), Boid (user-centered design studio), and representatives from Volvo Cars, Volvo Trucks, Geely Innovation & Collaboration, ZeekrTech, Autoliv's design/material units.

This diverse consortium ensured a blend of technical innovation, design practice, and industry relevance.

Contact persons: Kostas Stylidis (Intended Future), Berenice Gudiño & Karolina Kazmierczak (CIT), Katharina Merl (Boid), Lizete Druka (Volvo Cars), Magnus Andersson (Volvo Trucks), Lars Murgård (Geely), Emelie Heimersson (Zeekr Tech), Roald Lingbeek (Autoliv).