User Roles for Circular Product Development Software

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ABSTRACT

Global resource scarcity heightens the need to develop sustainable, circular products. Yet this is challenging due to interdependent criteria and the complexity of modern products. Model-based software can mitigate this by mapping key dependencies and evaluating designs for circular economy performance and sustainability. Before building such tools, user groups and roles must be clearly defined to protect sensitive data, improve user experience, and align workflows with stakeholder needs – especially those of developers. This paper defines roles for a model-based tool for circular and sustainable product development within the Cyclometric project. It introduces a methodology for role definition, followed by a formal evaluation of the developed roles.

1. INTRODUCTION

Designing sustainable, circular products requires addressing diverse criteria – sustainable manufacturability, recyclability, meaningful use, and long-lasting business models – across all development phases and the entire product life cycle. This is inherently complex due to interdependent criteria, differing approaches to closing material loops, and the complexity of products like cars or consumer electronics (Block, Ardilio, & Keicher, 2024). Model-based software tools can mitigate this complexity by mapping dependencies among

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these criteria, evaluating designs for circularity and sustainability, and providing a single source of truth for required data (see, e.g., (Schwahn, Potinecke, Block, Werner, & Tarlosy, 2024)). Yet, effective use of these tools requires clear user and role definitions to integrate sustainability into workflows, manage access, and align user experience (Akuthota, 2025; Herzberg, 2023; Lanchec, 2024). Existing engineering and lifecycle assessment software often comes with predefined roles (see e.g., (Capella, 2025; Dassault Systèmes, 2023; Oraby, Briem, Bippus, Rupp, & Zibek, 2024; SPARX SYSTEMS, 2025)). Yet the role definitions often focus on access permissions, interface settings, and the management of content and collaboration areas, but do not consider – nor support – the tasks within the development process of circular products. Thus, this publication defines and evaluates roles for a circular, model-based software tool from the perspective of circular development processes.

2. METHODOLOGY TO DEVELOP ROLES

Roles can be systematically derived from development process models. They outline product-development tasks and partially generalized roles. This paper adopts the Munich development process model as the foundational framework (Lindemann, 2009). The Munich process model is a systematic approach that structures development projects by dividing development into seven distinct phases (see Figure 1), each with specific goals and deliverables, facilitating continuous feedback and refinement. Five workshops were held, each with five to eight experts from the fields of sustainable product development, MBSE and LCA, to adapt this model towards circular product development. The experts collected tasks, necessary input and output information based on this adapted Munich process model. This data was then used to structure and define the user roles.

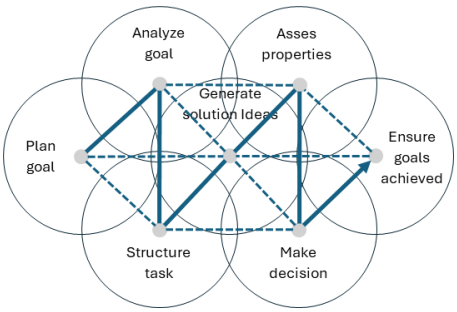

Figure 1: Munich development process model (Lindemann, 2009)

3. USER ROLES FOR CIRCULAR PRODUCT DEVELOPMENT SOFTWARE

Five roles where identified which are relevant for circular software tools: CE Problem Systemiser, CE System Analyst, CE Quality Tester, CE Solution Developer, and CE Solution Decision Maker (see Figure 2).

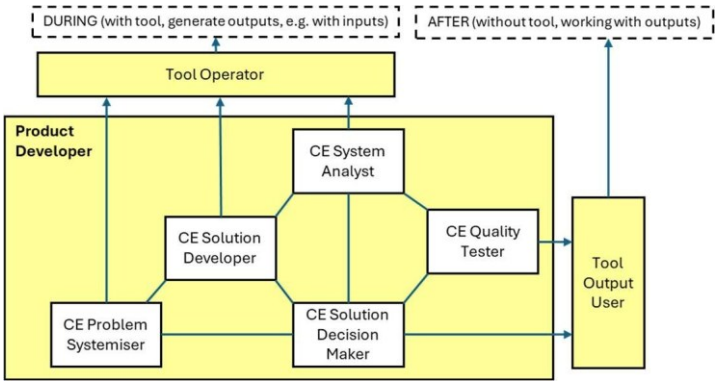

Figure 2: Definition CE Product Developer based on the Munich Model

The **CE Problem Systemiser** structures the CE problem by linking company goals to product architecture characteristics. Their focus is systematically determining relevant product characteristics where circular strategies can be applied effectively, in close collaboration with the CE Solution Developer and CE Solution Decision Maker. Furthermore, they prioritize design patterns to follow, structure the problem in terms of its dependencies and interfaces and define tasks per component, to focus the solution search.
The **CE System Analyst** identifies relevant design features from a structured understanding of the problem and quantifies sustainability impacts. They indicate the effects of circular design measures to provide reliable information for engineering design decisions. Their focus is analyzing product, material, and process characteristics for circularity, working with the CE Solution Developer, CE Quality Tester, and CE Solution Decision Maker.
The **CE Quality Tester** reviews planned CE strategies and evaluates risks of goal deviation. They ensure preventive goal achievement by verifying that circular measures fit requirements and by analyzing causes and impacts when issues arise.
The **CE Solution Developer** identifies effective circular measures, adapts the product's design and combines ideas into an overall concept, including

alternatives. They resolve conflicting goals and design circular, sustainable components, providing engineering design proposals to support decision-making.
The **CE Solution Decision Maker** evaluates solution ideas and alternatives against strategic requirements and company objectives and provides feedback on design drafts. They consider cost implications across design, production, and after-sales and make final selections of product architecture, materials, joining methods, and design details.

4. EVALUATION

An indicative application with an automotive manufacturer evaluated the role definitions. In a workshop with a sustainability officer, a sustainability expert, two engineers, and a project manager, we presented the roles embedded in a workflow of the MBSE software tool "CycloP" for early circular product development (see (BMBF, PTKA, 2025)). Currently, the manufacturer lacks a formal role model: A separate sustainability department (officer and LCA experts) performs LCAs on request and is weakly integrated with engineering. Consequently, the participants saw benefit in the role definitions, judged the roles suitable and aligned with engineering processes, and found them clear and complete. They noted the need to map roles to individuals within the development organization and integrate them with existing engineering roles. Consequently, this aspect still needs to be defined as it requires alignment with tasks already assigned based on existing engineering processes. In general, the roles were found to be sufficient for current tasks.

5. OUTLOOK

While the roles align with the evaluated practical requirements, broader validation is needed to confirm their applicability across diverse software tools and organizations. Future work should test the roles in varied tools and organizational contexts, with insights from these applications informing refinements. This will help ensure the roles remain adaptable and effective in different industrial environments.

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