D5.2 – GUI tool for decision making

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Abstract

Deliverable D5.2 presents the interactive conceptual-design tool that assists engineers during the early design phase by allowing fast evaluation of material choices, geometric options, and structural layouts. This tool was built using Python and offers a user-friendly workspace where designers can examine trade-offs between essential performance indicators and sustainability metrics at an initial design level. Through adjustable input parameters and clear visualizations of the design space, the platform enhances the clarity and effectiveness of decision-making.

In the frame of Fun4Design program, the interactive conceptual-design tool was implemented in the assessment of the design variants of A-Pillar automotive component.

Keywords: Conceptual design, A-Pillar, Python, Platform

Information Table

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Disclaimer

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Table of Contents

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List of Figures

1. INTRODUCTION – BRIEF DESCRIPTION OF THE DIGITAL DESIGN TOOL

Deliverable D5.2 focuses on the development of an interactive conceptual-design tool that supports early engineering decisions by enabling rapid exploration of materials, geometries, and structural configurations. The tool is developed in Python tKinder (Tk 8.6) [1] and provides an intuitive environment where users can investigate trade-offs between key performance and sustainability parameters at a preliminary design stage. By offering control of the input design parameters and visual representation of the design exploration, the digital platform aims to improve decision-making efficiency and transparency, ultimately forming the foundation for an open-access benchmark tool that can be expanded with new datasets and modelling capabilities over time.

In the frame of Fun4Design program, the interactive conceptual-design tool is implemented in the assessment of the design variants of A-pillar automotive component. The case study is a multi-material A-pillar component that was presented in previous studies [2,3]. The assessment is performed based on a holistic sustainability approach presented in previous research works [4]. According to this approach, the sustainability is considered holistically as the trade-off of different design aspects (pillars), namely performance, cost, environment, social and circularity. The main output of this approach is the holistic Sustainability Index (SI) that evaluates the design variant's sustainability on a relative scale from 0 (lowest) to 1 (highest). This approach reflects degrees of sustainability rather than absolute values, as results are always referenced to a baseline [5]. Social pillar is not considered in the current study, since social acceptance is generally tied to complete products that satisfy user needs (e.g., cars, aircraft, ships) rather than to individual components. At the component level, such as A-pillar component, it remains unclear how social impact can be meaningfully quantified, making environmental, economic, and performance factors the primary focus here.

In this report, a demonstration of the developed Graphical User Interface (GUI) tool is presented for assessing A-pillar design variants. The dataset used to feed the GUI is generated through finite element (FE) simulations conducted in ANSYS 2024R2 [5], focusing on three-point bending of the proposed design concepts. The simulations evaluate not only the mechanical performance metrics of each A-pillar variant, but also cost, environmental, social, and circularity design pillars metrics. Key output indicators include maximum bending stress (MPa), total mass (kg), CO_2 emissions (kg/ CO_2), and total cost (€) for each design variant.

2. DEMONSTRATION OF THE DIGITAL DESIGN TOOL

The digital platform opens with a home page that provides an overview of the tool’s objectives and functionality, introducing the user to the interface and its capabilities.

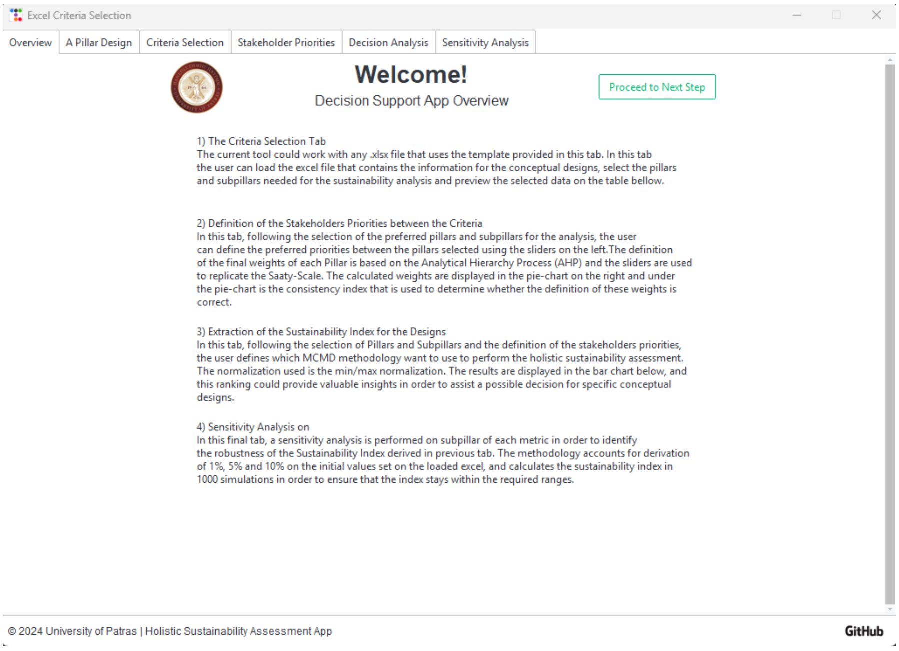

Figure 9. Home page.

Next, the user configures the A-pillar design variant by selecting its individual components, beginning with the cross-sectional profile of the metallic base (Circular, Trapezoid, or Rectangular). This selection subsequently defines the available options for the composite layer and composite rib structure.

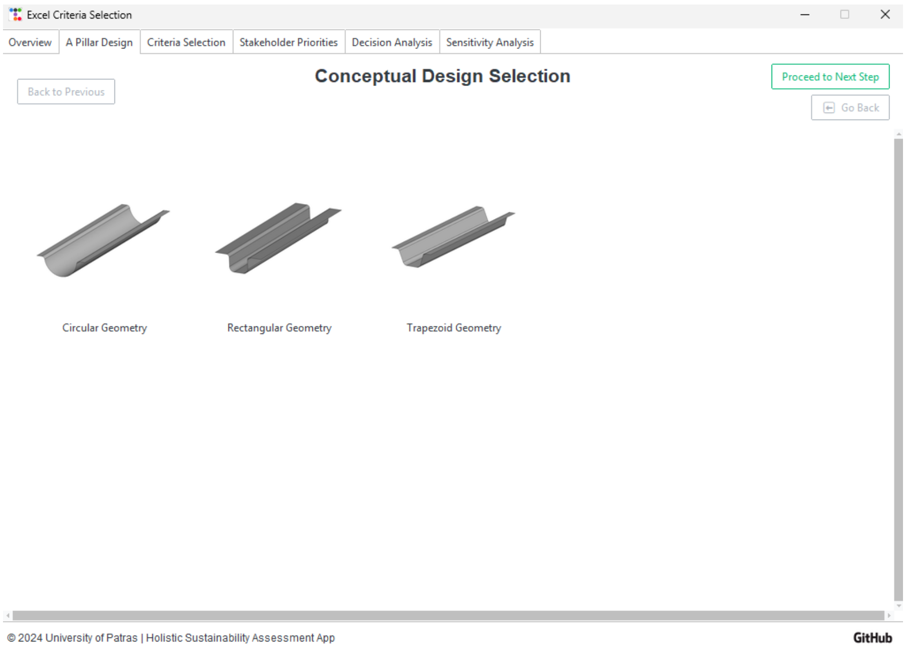

Figure 10. Geometry - Cross-sectional profile selection.

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Subsequently, the internal rib configuration is selected, choosing among rectangular, triangular, or cross-rib layouts.

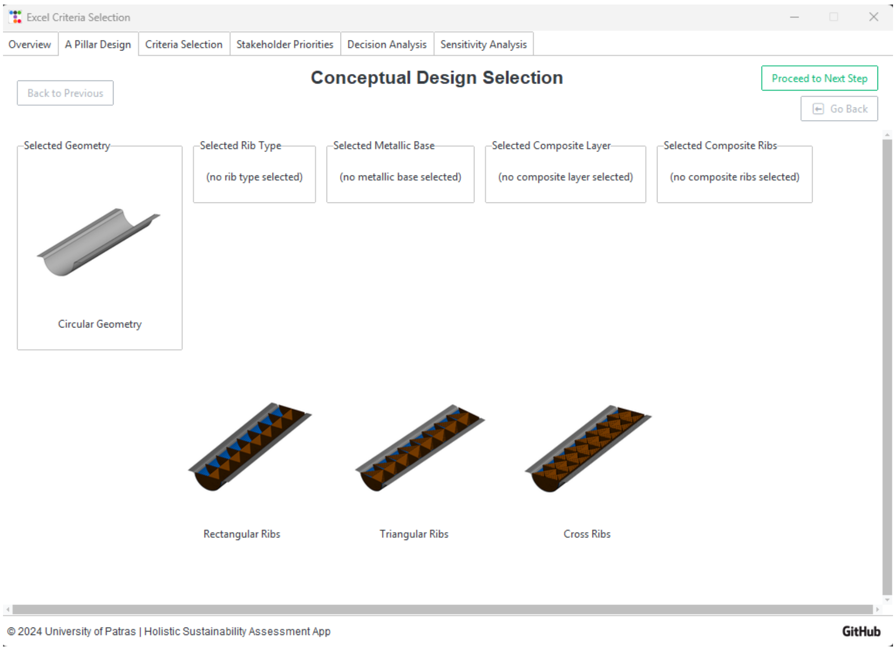

Figure 11. Geometry – Rib structure layout selection.

The platform then guides the user through the material selection for each component (metallic base, composite layer, and composite ribs). The available options include commonly used metallic and composite materials applied in modern automotive structures.

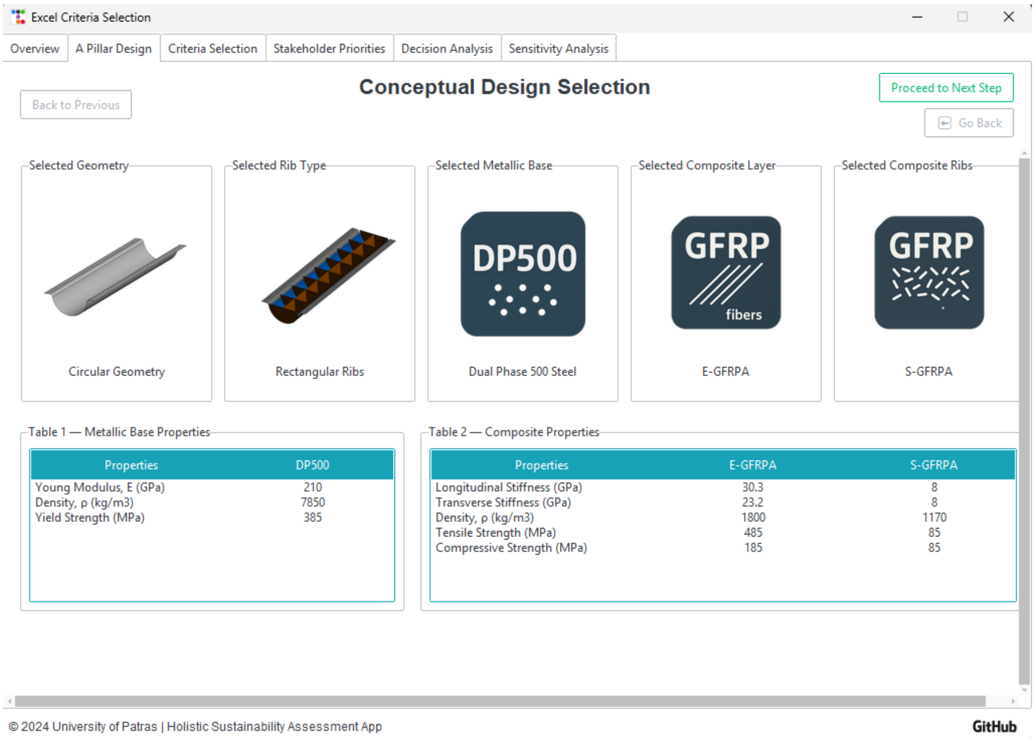

Figure 12. Materials selection.

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Once the A-pillar configuration is defined, the platform proceeds to the selection of holistic sustainability pillars and metrics that will be used for design evaluation. Appropriate weight factors are then assigned using the Saaty scale, reflecting the prioritisation of the design objectives for each case.

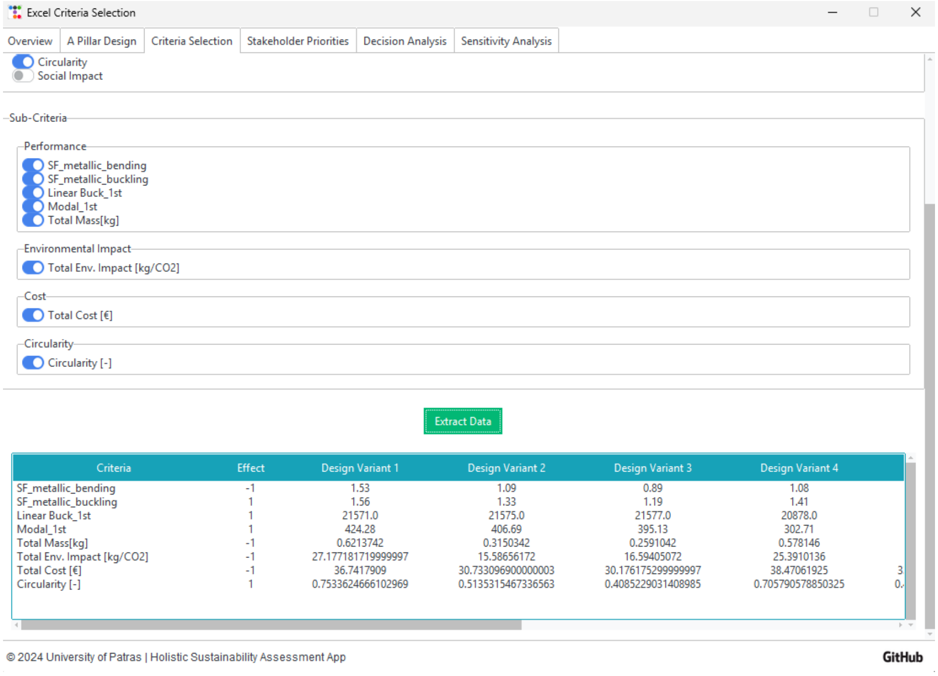

Figure 13. Sustainability metrics selection.

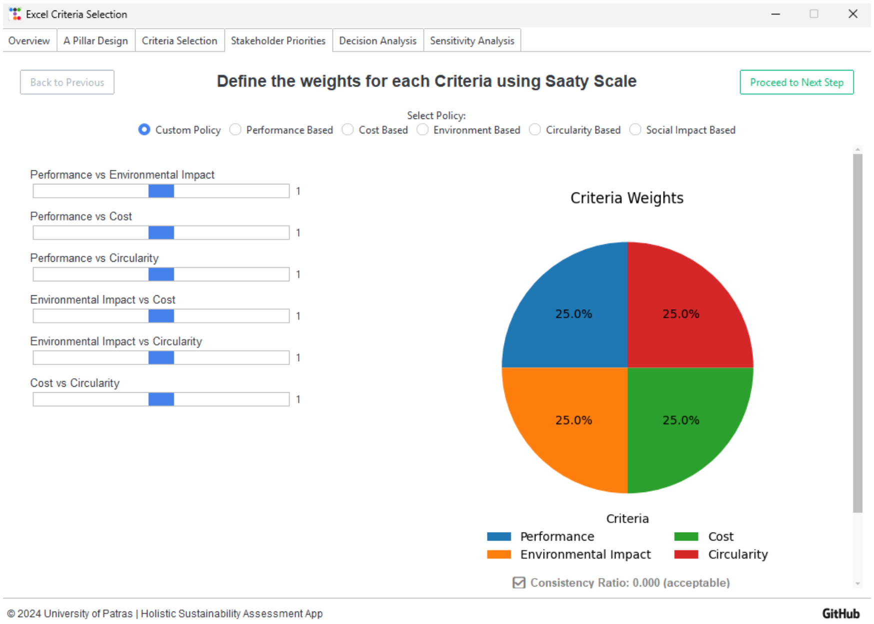

Figure 14. Sustainability pillars weight factors selection.

Finally, the SIs for the examined design variants are calculated and displayed, along with a ranking of all alternatives in descending order. A sensitivity analysis is subsequently performed by introducing 1%, 5%, and 10% variations to the input metrics, allowing assessment of the impact of these changes on the final ranking.

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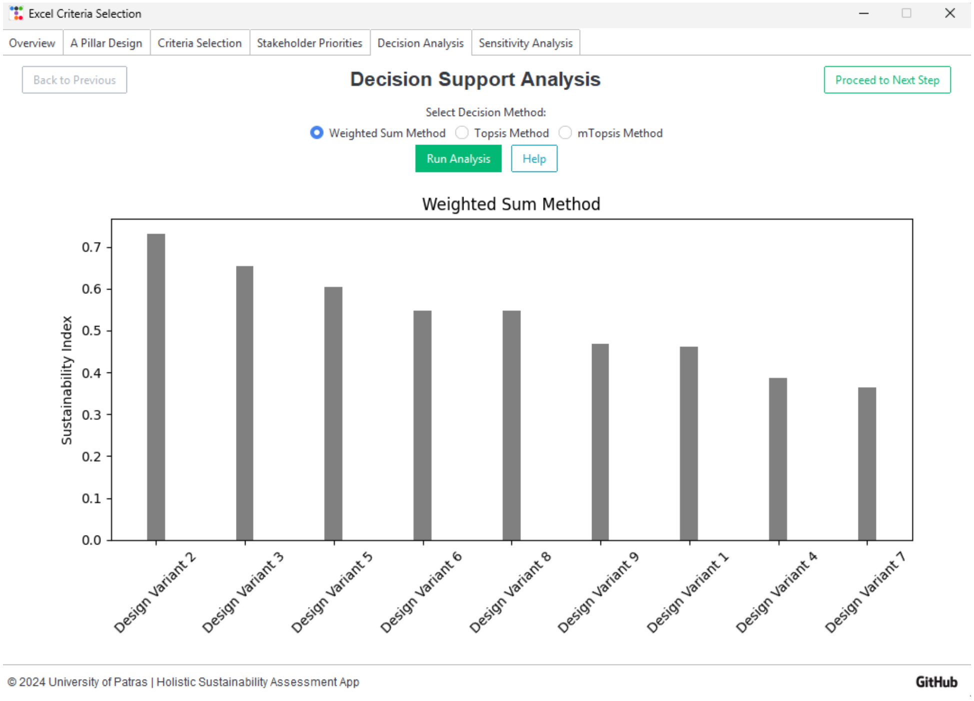

Figure 15. Ranking of the design variants.

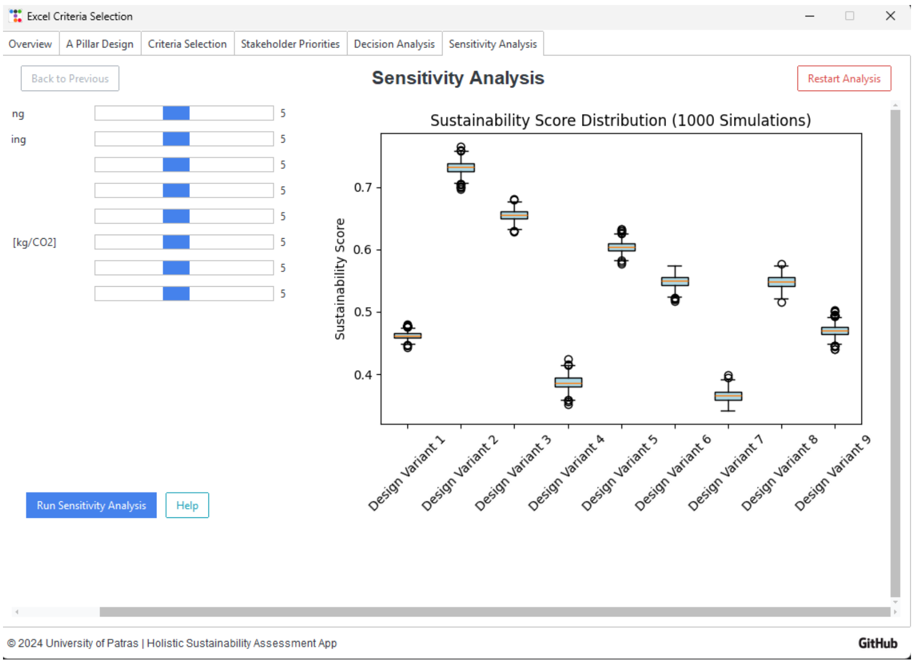

Figure 16. Sensitivity analysis.

The current library of geometries and materials can be progressively expanded with additional variants and materials, as well as new structural component types. This will further demonstrate the flexibility of the digital platform, enabling broader applicability and richer design exploration capabilities.

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