



Fun4Design

D6.1 – Conference disseminating conceptual design of demonstrator

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Abstract

Deliverable D6.1, titled “*Conference Disseminating Conceptual Design of Demonstrator*”, is part of WP6 of the Fun4Design project. We present two different demonstrators, with emphasis on the conceptual design in the automotive (A-Pillar frame) and aviation (aircraft sustainable design) sectors.

These works were presented at International Conference of Engineering Against Failure (ICEAF) VIII.

This deliverable provides a brief introduction to the conference papers and includes the presentation slides.

Keywords: Conceptual design, Demonstrator, A-Pillar, Aircrafts, Conference papers

Information Table

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Sub-action	Sub-action 1. Funding New Researchers – RRF: Basic Research Financing (Horizontal support for all Sciences)
Acronym	Fun4Design
Proposal Title (EN)	Function-oriented, multi-material design of sustainable mechanical systems
Proposal Title (EL)	Σχεδιασμός βιώσιμων μηχανικών συστημάτων από πολλαπλά υλικά με προσανατολισμό στις λειτουργίες
Scientific Area	SA2. Engineering Sciences & Technology
Scientific Field	2.3 Mechanical engineering
Scientific Subfield	2.3.5 Manufacturing engineering and machine design
Host Institution	UNIVERSITY OF PATRAS
Department	DEPARTMENT OF MECHANICAL ENGINEERING AND AERONAUTICS
Non-beneficiary Collaborating Organization(s)	TU DRESDEN
Keywords	Sustainable engineering, conceptual design, recycled composites, machine learning, multi-criteria decision making, mechanical systems, function-integration, design-from recycling, recyclability, sustainability
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George Kouvaras	PhD Researcher, UPATRAS	30.08.2025

Approved for submission by		
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Eidikos Logariasmos Kondilion kai Ereunas University of Patras	Coordinator - UPatras	19/11/2025

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Disclaimer

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1 INTRODUCTION

The submitted conference papers focused on disseminating the outcomes of the Fun4Design project. In **M19**, the conference paper (C1), titled: “ ***Towards a Machine Learning-Driven Sustainable Design of an A-Pillar Automotive Component*** ” was presented at the [International Conference of Engineering Against Failure \(ICEAF\) VIII](#). This study presents a data-driven approach for optimizing the design of an A-pillar multi-material component by the employment of Machine Learning (ML) models. An extensive series of nonlinear Finite Element (FE) analyses was conducted to generate a dataset capturing the mechanical performance, environmental impact, and cost metrics of various design variants for different geometric configurations and materials. The dataset was then used to train ML models based on linear regression to predict optimal design configurations according to predefined criteria. Design variants meeting holistic sustainability criteria were subsequently evaluated through FE simulations to verify the ML model predictions. The results demonstrate the effectiveness of this demonstrator in facilitating data-driven design optimization for automotive engineering. This design approach provides real-time decision-making support, allowing engineers to identify optimal configurations more rapidly and accurately than traditional design processes.

Also, the conference paper (C2) titled “***Promoting Sustainability in Aviation Engineering Through an Interactive Educational Platform***”, presented at the [International Conference of Engineering Against Failure \(ICEAF\) VIII](#), demonstrates a versatile approach to sustainable design that can be applied across multiple engineering sectors. The study, carried out in close collaboration with the Computer Engineering Department of the University of Patras (CEID), focused on sustainable aircraft design by developing a demonstrator based on a holistic sustainability framework encompassing environmental, technical, economic, and social dimensions. CEID contributed expertise in computational methods and VR technology, enabling the development of an interactive platform where users can explore virtual aircraft models and evaluate their sustainability performance across key metrics such as fuel efficiency, emissions, and recyclability. The platform was implemented for educational purposes with students in the Department of Mechanical Engineering and Aeronautics, providing an ideal context to test the methodology beyond automotive applications. Developed within the scope of the Fun4Design project, this work illustrates how its methodology for multi-criteria sustainability assessment is generalizable to sectors such as aerospace, leveraging the host institution’s expertise while showing the potential for broader adoption in early-stage design and decision-making across engineering disciplines.

Details of the Conference Presentations can be found in **Annex 1** and **Annex 2**.

ANNEX 1: Conference Presentation (C1)

Towards a Machine Learning-Driven Sustainable Design of an A-Pillar Automotive Component

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¹Department of Mechanical Engineering & Aeronautics, University of Patras, Greece

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Aim of the present research

- Machine Learning (ML) for data-driven optimization of A-pillar sustainable design is developed.
- Input to ML models: Finite Element (FE) analyses generate a dataset on mechanical performance, environmental impact, and cost for various geometries and materials.
- Also, the holistic sustainability index is integrated in the design including structural performance, environmental impact, and cost.
- The results ML models are further verified with FE simulations.

Lightweight Design of A-pillar → Finite Element model → Dataset for training → Machine Learning model → Sustainable design of the A-pillar

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Demonstration of the methodology: A-Pillar Automotive Component

Multifunctional material combinations, appropriate for automotive applications have been considered.

No	Base profile	Composite layer	Rib structure
1	DP500 Steel	E-GFRPA*	S-GFRPA*
2	Al 6111 T8x	E-GFRPA*	S-GFRPA*
3	Mg-Al-Zn AZ91D	E-GFRPA*	S-GFRPA*

*Glass Fiber (GF) laminate in polyamide PA matrix [1]
**Short Glass Fiber in polyamide PA matrix [1]

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Parametric Design and Boundary Conditions II.

2-Point Bending Boundary Conditions

Multizone method
Element size = 5 mm
35000 hexahedral elements

FE model

Constraints	Parameters		Requirements	
	Variables	Parameters	Structural	Sustainability
Safety Factor: between 1.5-2.5	Cross-sectional profiles	Stress	Design space: 280x90x42 mm	Minimization of costs
	Thickness of A-pillar (base profile, composite layer and ribs)	Environmental impact	Total mass	Safety factor: 1.5-2.5
	Materials	Cost	No damage should occur	Minimization of environmental impact

	DP500 Steel	Al 6111	Mg-Al-Zn	E-GFRPA	S-GFRPA
Manufacturing	Roll Forming	Roll Forming	Die Casting	Autoclave	Autoclave
Disposal	Recycle	Recycle	Recycle	Downcycle	Downcycle
CO ₂ footprint (kg)	42.8	52.2	89.3	46.5	46.6
Part cost (€/kg)	1.205	3.27	10.84	157	157

All properties are determined using ANSYS GRANTA's Eco Audit Tool software based on:
 • estimated average age of light diesel in Europe (14 years),
 • estimated average mileage of light diesel in Europe (65 km), and
 • average number of days a car usage per year (350 days) [2].

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Function-oriented, Multi-material Design Of Sustainable Mechanical Systems (Fun4Design)

Objectives

- Develop methodologies for the structural design of sustainable mechanical systems
- Integrate sustainability & recyclability considerations into the early design phase
- Create a decision-making tool utilizing state-of-the-art machine learning algorithms

I: Analysis of main and secondary functions for representative geometries in A-Pillar structure [1]
 • A-Pillar Geometry
 • Material choice

II: Parametric design and simulations for database generation

III: Development of a ML-algorithm for Sustainable Design

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The proposed index to measure sustainability

$$SI = (K_P \times P) + (K_C \times C) + (K_E \times E) + (K_{CIRC} \times CIRC) + (K_{SOC} \times SOC)$$

Sustainability Index

Performance Criteria
Costs Criteria
Environmental Impact Criteria
Circularity Performance Criteria
Social Impact/Acceptance Criteria

A hybrid MCDM (AHP + Weighted Sum) is proposed to obtain the aggregated metric of sustainability.

K_P, K_C, K_E, K_{CIRC} and K_{SOC} are subjective weight factors obtained from the AHP (Analytic Hierarchy Process) Saaty scale, reflecting the importance of each term to the overall Index value.

A min-max normalization is employed to normalize the considered metrics to a 0-1 range.

Numerical value	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate values

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Parametric Design and Boundary Conditions I.

Design Configurations

Rectangular (REC)
Semi-circular (CIRC)
Trapezoidal (TRPZ)

Base Metallic Profile
With Composite Layer
With Composite Rib Structure

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Dataset Generation

Design Inputs

Parametric FE models

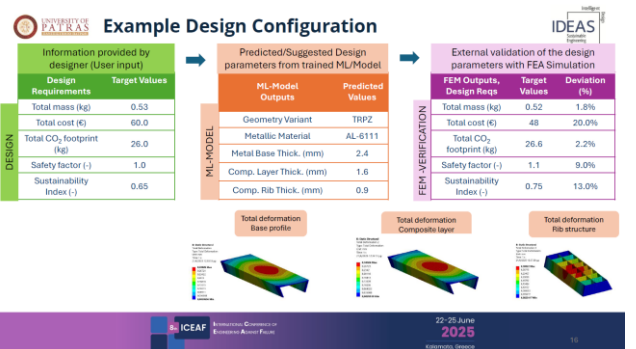
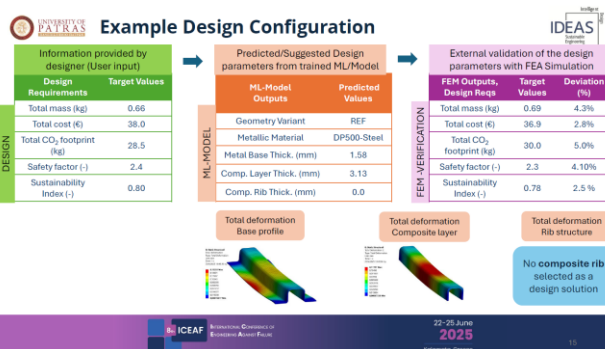
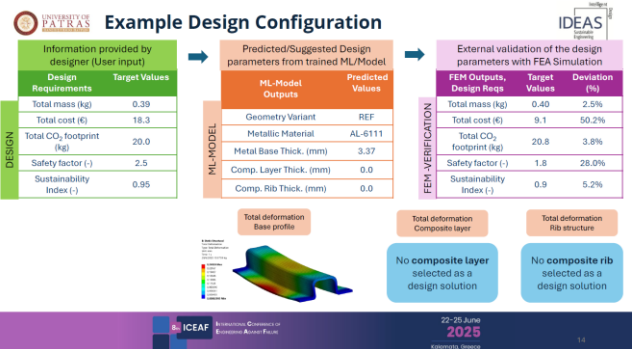
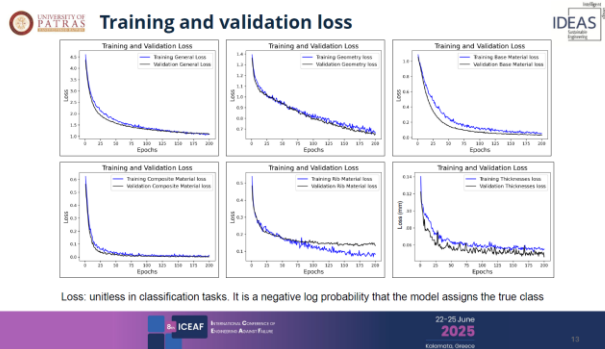
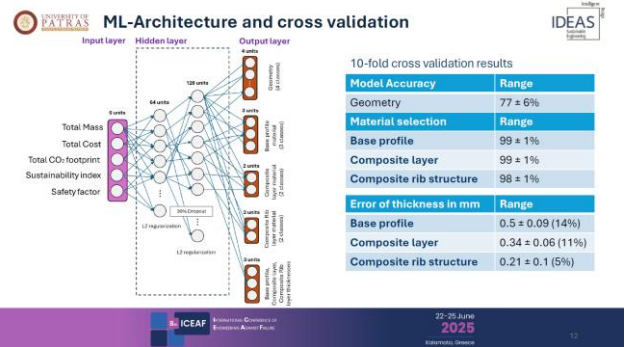
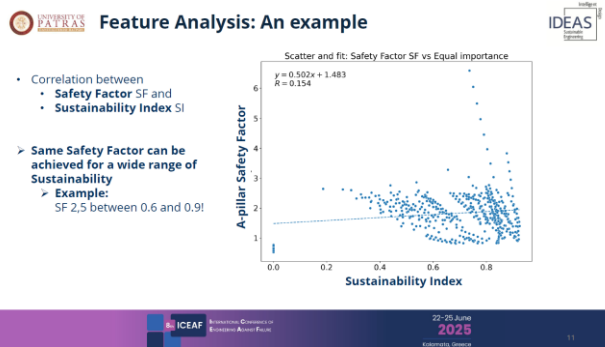
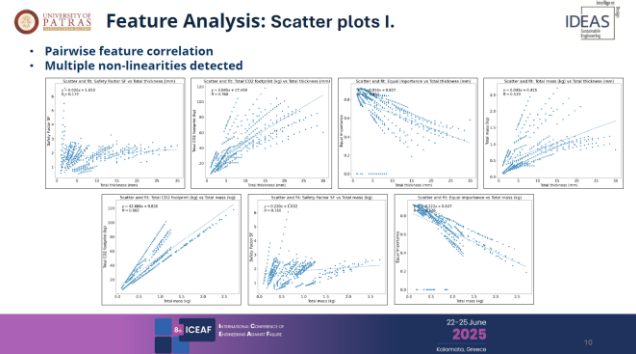
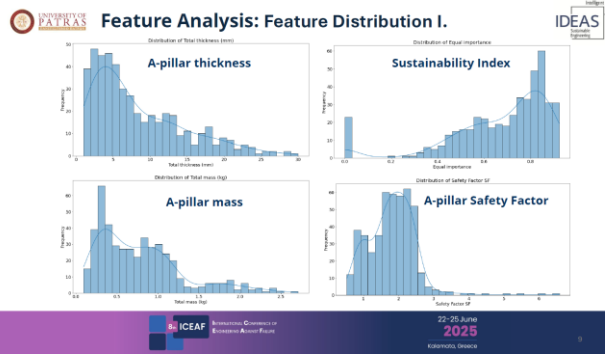
Preview of Dataset with Numeric Values for all Design Configurations

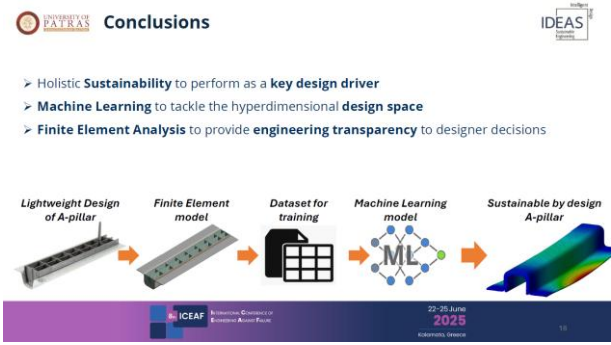
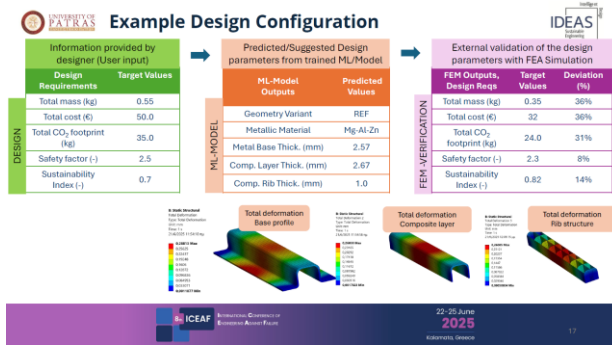
Design Configurations	Rectangular (REC)				Semi-circular (CIRC)				Trapezoidal (TRPZ)			
	Base Metallic Profile	With Composite Layer	With Composite Rib Structure	Base Metallic Profile	With Composite Layer	With Composite Rib Structure	Base Metallic Profile	With Composite Layer	With Composite Rib Structure			
Design Space	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm	280x90x42 mm		
Material	DP500 Steel	Al 6111	Mg-Al-Zn	E-GFRPA	S-GFRPA	DP500 Steel	Al 6111	Mg-Al-Zn	E-GFRPA	S-GFRPA		
Stress	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa	157 MPa		
Mass	1.205 kg	3.27 kg	10.84 kg	157 kg	157 kg	1.205 kg	3.27 kg	10.84 kg	157 kg	157 kg		
CO ₂ footprint (kg)	42.8	52.2	89.3	46.5	46.6	42.8	52.2	89.3	46.5	46.6		
Part cost (€)	1.205	3.27	10.84	157	157	1.205	3.27	10.84	157	157		

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ANNEX 2: Conference Presentation (C2)

Promoting Sustainability in Aviation Engineering Through an Interactive Educational Platform



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²Computer Engineering and Informatics Department, University of Patras, Greece

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 Funded by the European Union
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Motivation

GLOBAL CO₂ EMISSIONS FROM TRANSPORTATION

Mode	Percentage
ROAD (passenger)	45.1%
ROAD (freight)	29.4%
AVIATION	11.6%
SHIPPING	10.6%
RAIL	1%
OTHER	2.2%

This percentage translates to more than 1 billion tons of CO₂ emitted annually.



Source: The World is They based on International Energy Agency and the International Council on Clean Transportation

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Research Background

Implementation of a Holistic MCDM-Based Approach to Assess and Compare Aircraft, under the Prism of Sustainable Aviation

by Dionysios N. Markatos¹ and Sotiris G. Pantazis¹

Library of Technology & Strength of Materials, Department of Mechanical Engineering & Aeronautics, University of Patras, 26500 Patras, Greece
¹ Author to whom correspondence should be addressed.

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 Submission received: 5 January 2022; Revised: 20 February 2022; Accepted: 27 February 2022
 Published: 1 March 2022
 (This article belongs to the Special Issue Advances in Aerospace Sciences and Technology II)

Integrating Sustainability in Aircraft Component Design: Towards a Transition from Eco-Driven to Sustainability-Driven Design

by Angelika Filippatos¹ and Sotiris G. Pantazis¹

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Accepted: 2022, 1505, 1461, <https://doi.org/10.3390/aircraft100201461>
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 Published: 16 February 2022
 (This article belongs to the Special Issue 19th EASD International Conference on Innovation in Aviation & Space Systems Sustainability: Theory & Technology)



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Aircraft Selection



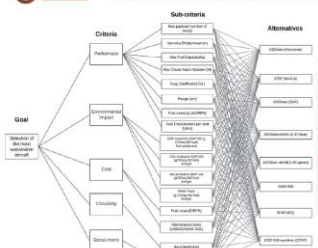
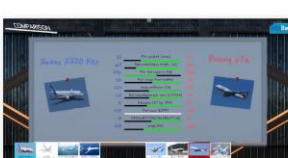
Short haul and Long-haul aircraft



Consideration of alternative fuels

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Aircraft Assessment and Comparison

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Indicative 3D A/C models



Source: Sketchfab



Source: Sketchfab

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Involved Software/Hardware



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Aircraft Hangar View



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Cabin Interior View



Realistic Cabin Interior View 1



Realistic Cabin Interior View 2



Interactive Nature



Interaction with NPC's (non-playable characters) – mini games (aircraft maintenance tasks, participation in quizzes, etc.)



Interactive Nature



Visualization of flight range



Set up the Departure



Piloting of the Platform



Where



Arsakeion of Patras is considered one of the most modern schools in Greece and the Balkans

Participants

Over 200 gymnasium and lyceum students from 5 different schools of the Patras region:

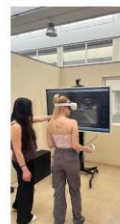
- Arsakeion Gymnasium (17 students – 1 teacher)
- Rion Gymnasium (45 students – 3 teachers)
- Rion Lyceum (44 students – 3 teachers)
- Agios Vasilis Gymnasium (49 students – 4 teachers)
- Patras 7th Gymnasium (51 students – 4 teachers)



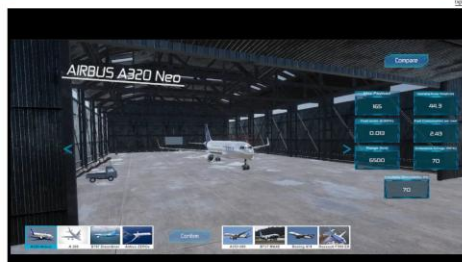
Piloting – High school students



Piloting – MEAD students



Platform Demo



Conclusions



- A virtual reality (VR) platform addressing the sustainability of the aviation sector was developed as an educational module utilizing gamification.
- Positive feedback and well-received by both school and university students.
- The requirement for multiple VR headsets results in high implementation costs.
- Fast-paced technological advancements may quickly render the equipment outdated, potentially reducing engagement among students accustomed to modern gaming standards.





What's next




- Further development and enrichment of the platform (incorporation of more mini-games relating to sustainability, increased interaction for the students and experimenting with aircraft characteristics, new environments and features, and additional aircrafts.
- Continue the demonstration of the platform to school and college students through the 'students go to university' initiative and in the frame of other research and teaching frameworks, e.g. through Erasmus projects.






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Website: [Fun4Design.IDEAS\(upatras.gr\)](http://Fun4Design.IDEAS.upatras.gr)








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