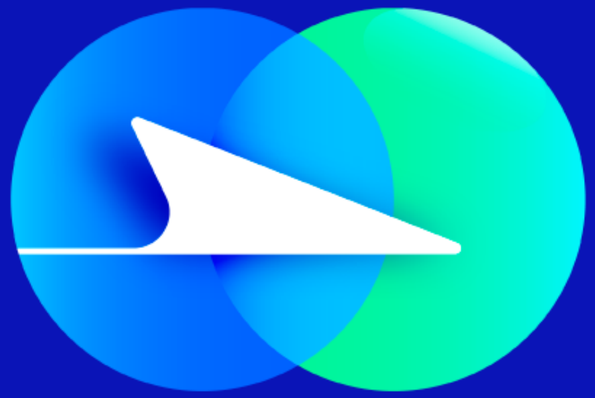
refmap

Funded by the European Union



AVIATION TWIN TRANSITION CLUSTER

A EUROPEAN INITIATIVE FOR A SUSTAINABLE FUTURE

AVIATION
TWIN TRANSITION
CLUSTER

refmap

Funded by
the European Union

RefMap Clustering Event 2025

Advancing Sustainable Aviation & Urban Air Mobility

Holistic Assessment and Design Approaches Towards Sustainable Aviation

Prof. Angelos Filippatos,
Department of Mechanical Engineering and Aeronautics, University of Patras

Intelligent Design
IDEAS
Sustainable Engineering

29–30 July 2025, Athens, Greece

AVIATION
TWIN TRANSITION
CLUSTER

refmap

Funded by
the European Union

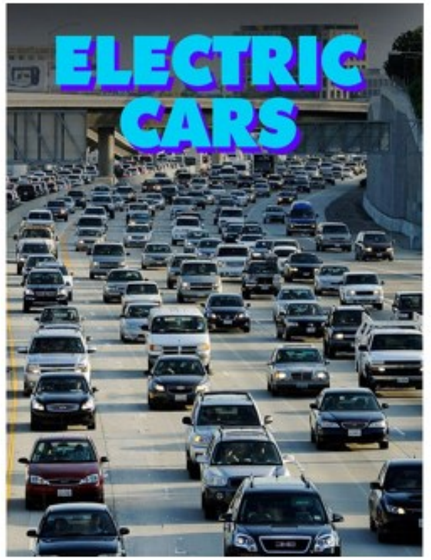
What is truly sustainable ?

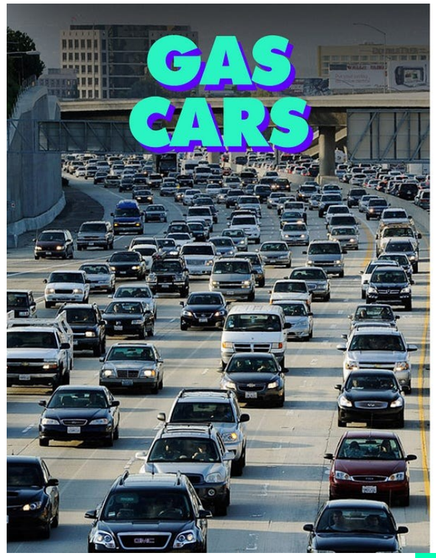
Sustainable (?) Aviation

Jet fuel airplanes

Sustainable airplanes

Sustainable (?) Mobility





AVIATION
TWIN TRANSITION
CLUSTER

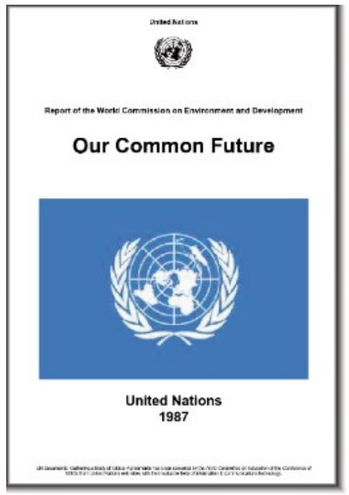
refmap

Funded by
the European Union

A sustainable aviation?

Clean Aviation's ultimate objective is **to reach net-zero greenhouse gas emissions, and to enable a climate- neutral aviation system in Europe by 2050**.

Sustainability: Understanding the Basics



- In 1987, the **'Our Common Future' report** by the UN Brundtland Commission was published. It is considered **one of the most regarded, simplified definitions in the sustainability movement**, which made the term *sustainable development, popular:*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [1]

- The Sustainable Development Goals (SDGs)[2], were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.
- They are considered as the pathways to achieve sustainability at the long-term

[1] Idowu, S.O.; Capaldi, N.; Zu, L.; Gupta, A.D. (Eds.) Encyclopedia of Corporate Social Responsibility; Springer: Berlin/Heidelberg, Germany, 2013; ISBN 978-3-642-28035-1.
[2] THE 17 GOALS | Sustainable Development (un.org)

Sustainability in aviation

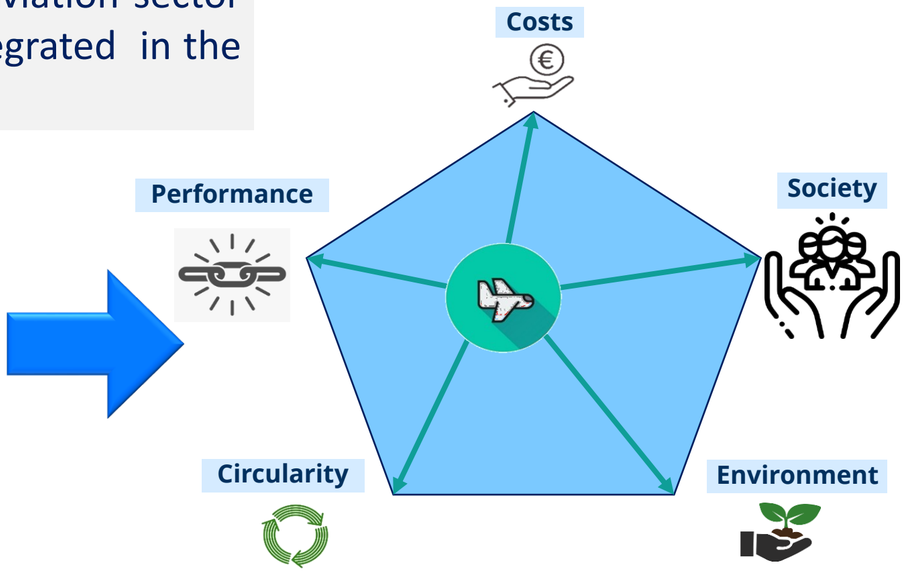
- In the aviation sector, sustainability is interpreted primarily as environmental sustainability and is mainly focused on the decarbonization of the sector.
- Environmental sustainability is crucial for the viability of the sector; however, it is only a part of a bigger picture.
- In aviation today, the design process is primarily guided by considerations of weight reduction and cost efficiency.

Notable progress has been made in eco-design, also evident in initiatives within the aviation sector such as **Clean Sky 2 and Clean Aviation**; yet, ecoDESIGN approaches are still hardly integrated in the aviation sector.

eco DESIGN

Eco-design standard: ISO 14062:2002 - EN ISO 14006:2011

Eco-design is understood as the integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts



A proposed index to measure sustainability

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

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

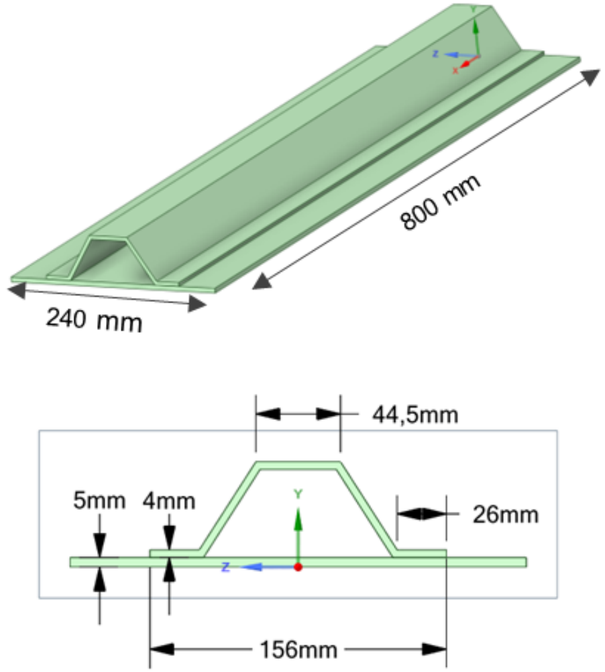
*Markatos, D.N.; Pantelakis, S.G. Assessment of the Impact of Material Selection on Aviation Sustainability, from a Circular Economy Perspective. Aerospace 2022, 9, 52. https://doi.org/10.3390/aerospace9020052

*Filippatos, A.; Markatos, D.; Tzortzinis, G.; Abhyankar, K.; Malefaki, S.; Gude, M.; Pantelakis, S. Sustainability-Driven Design of Aircraft Composite Components. Aerospace 2024, 11, 86. https://doi.org/10.3390/aerospace11010086

refmap
Funded by the European Union

Aviation Component Level Demonstration

Use case: Hat Stiffened Panel with multiple material combinations/ geometrical configurations



Reference geometry

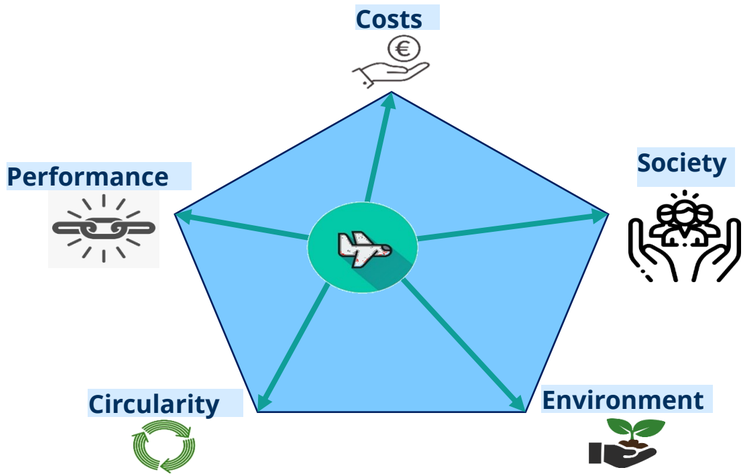
Multiple **material combinations**, appropriate for aerospace applications have been considered

	Component Configurations	
No	**Skin**	**Stringer**
1	Aluminium 2024 T3	Aluminium 2024 T3
2	CFRP	Aluminium 2024 T3
3	Aluminium 2024 T3	CFRP
4	CFRP	CFRP
5	17-4PH Stainless Steel	CFRP

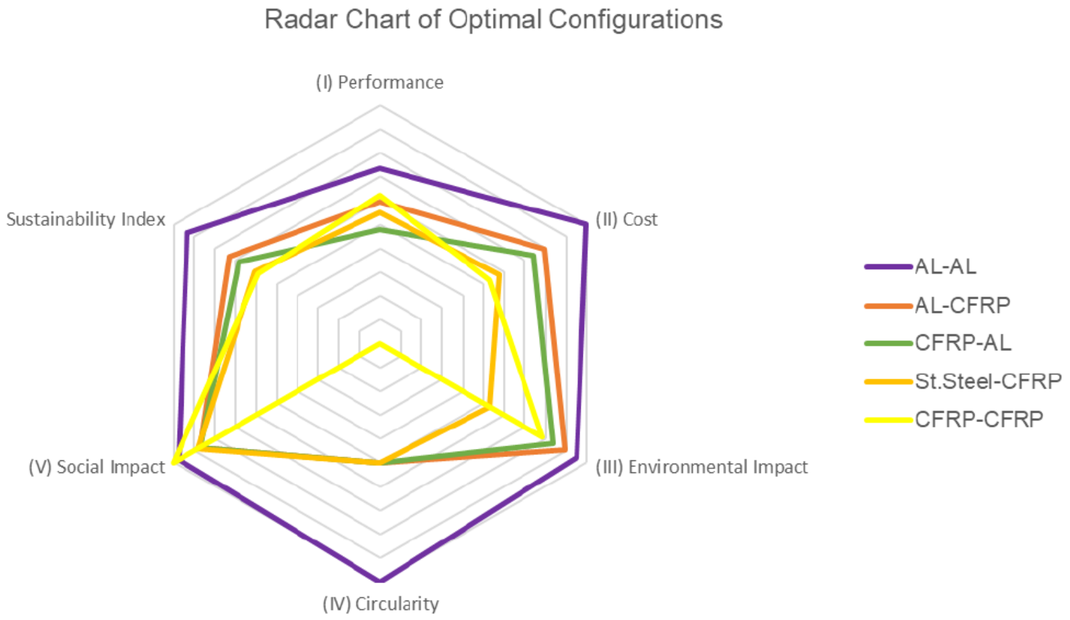
Reference case material combination

Filippatos, A.; Markatos, D.; Theochari, A.; Pantelakis, S. Integrating Sustainability in Aircraft Component Design: Towards a Transition from Eco-Driven to Sustainability-Driven Design. *Aerospace* **2025**, *12*, 140. https://doi.org/10.3390/aerospace12020140

Sustainability Assessment Results
Cradle-to-gate



$$SI = K_P \times P + K_C \times C + K_E \times E + K_{CIRC} \times CIRC + Ksoc \times SOC \leq 1$$



Equal Weights scenario

Design Configurations Ranking		
Thickness skin (mm)	Thickness stringer (mm)	Crown width (mm)
No.1 - Aluminium - Aluminium - SI = 0.912 ± 0.011		
5.40 ±0.46	5.31 ± 0.59	47.94 ± 8.93
No.2 - Aluminium - CFRP - SI = 0.667 ± 0.033		
5.30 ± 0.51	4.58 ± 0.95	51.13 ± 9.07
No.3 - CFRP - Aluminium - SI = 0.625 ± 0.029		
4.85 ± 0.81	5.36 ± 0.55	47.74 ± 9.10
No.4 - St.Steel-CFRP - SI = 0.553 ± 0.027		
5.25 ± 0.55	4.72 ± 0.91	49.77 ± 9.41
No. 5 - CFRP - CFRP - SI = 0.486 ± 0.047		
4.50 ± 0.94	4.50 ± 0.94	50.00 ± 9.42

AVIATION
TWIN TRANSITION
CLUSTER

refmap

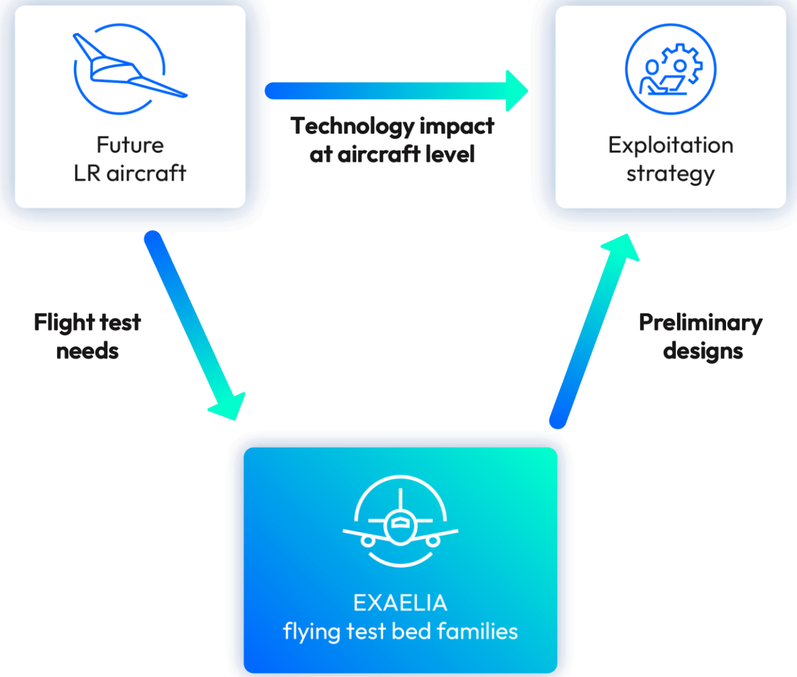
Funded by
the European Union

Aircraft Level

EXAELIA
Flying Testbeds for Novel Long-Range Aircraft

EXAELIA: Towards flying testbeds for novel long-range aircraft

Call: HORIZON-CL4-2021-RESILIENCE-01



Project Objectives:

Investigate the potential emissions reduction of long-range air traffic offered by promising blended wing body aircraft configurations and by hydrogen-powered tube-and-wing configurations, including their constituting radical new technologies.

Develop roadmaps, but also operational and business plans, for the further development of the EXAELIA flying testbeds and the use of these assets in the development of the future long-range aircraft.

Duration: 42 Months
Budget: 16.2 Mio EUR
Partners: 23

AVIATION
TWIN TRANSITION
CLUSTER

Framework Level

IMPACT MONITOR: technology and policy assessment of the environmental-, economic- and societal-impact of European aviation R&I. Call: HORIZON-CL5-2022-D5-01

IMPACT MONITOR II

IMPACT MONITOR

Project Objectives:

Assessment framework & toolbox
Evolve an assessment framework/toolbox that provides a systematic approach of the complete cycle of performing holistic environmental, economic and societal impact assessments of European aviation R&I

Collaborative assessment framework
Develop a scalable, open source, distributed, multidisciplinary, modular, and model independent collaborative assessment framework & toolbox to support holistic impact monitoring

Multi-level use cases
Demonstrate the collaborative framework robustness via multi-level use cases

Interfaces with key stakeholders
Establish interfaces with, and reach out to key stakeholders in European aviation R&I

Impact Monitor Academy
Educate students and broader community with broader access to the assessment toolbox and the collaborative assessment framework through initiating an Impact Monitor Academy

Duration: 24 Months
Budget: 2,2 Mio EUR
Partners: 10

Project's Methodology

AVIATION
TWIN TRANSITION
CLUSTER

refmap

Funded by
the European Union

Take Away

1. Sustainability needs to be Defined in the Aviation Sector, towards Common Paths to Global Sustainability Goals

2. Holistic Definitions and Integration of Sustainability to Design Methodologies become Crucial as the New-Generation Aviation Systems are Developed

3. To be Useful in everyday Engineering, Sustainability Assessment needs to be Applicable in Multi-Level Approaches.

AVIATION
TWIN TRANSITION
CLUSTER

refmap

Funded by
the European Union

thank you
for your attention!

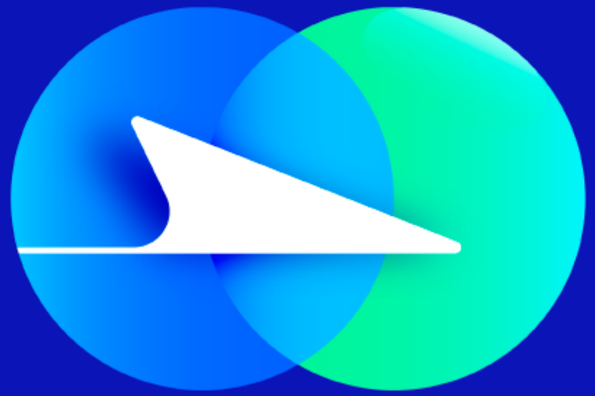
Intelligent Design
IDEAS
Sustainable Engineering

For more information:
www.refmap.eu

Q&A / Closing

refmap

Funded by the European Union



AVIATION TWIN TRANSITION CLUSTER