



EXAELIA

Flying Testbeds for Novel Long-Range Aircraft

Identification of Sustainability-related Stakeholder Needs and Requirements for the Conceptual Design of Future Long-Range Aircraft

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Aim of the present work

- **Sustainability-driven design approach** for Future Long-Range Aircraft (FLRA).
- Analysing the relation between the **current and the future FLRA** with sustainability.
- Aligning **stakeholder needs** with the relevant sustainability design aspects.
- **Systems engineering approach** for the translation of stakeholder needs into structured aircraft design requirements that reflect broader sustainability goals.

Project: EXAELIA EU HORIZON2020

Goal

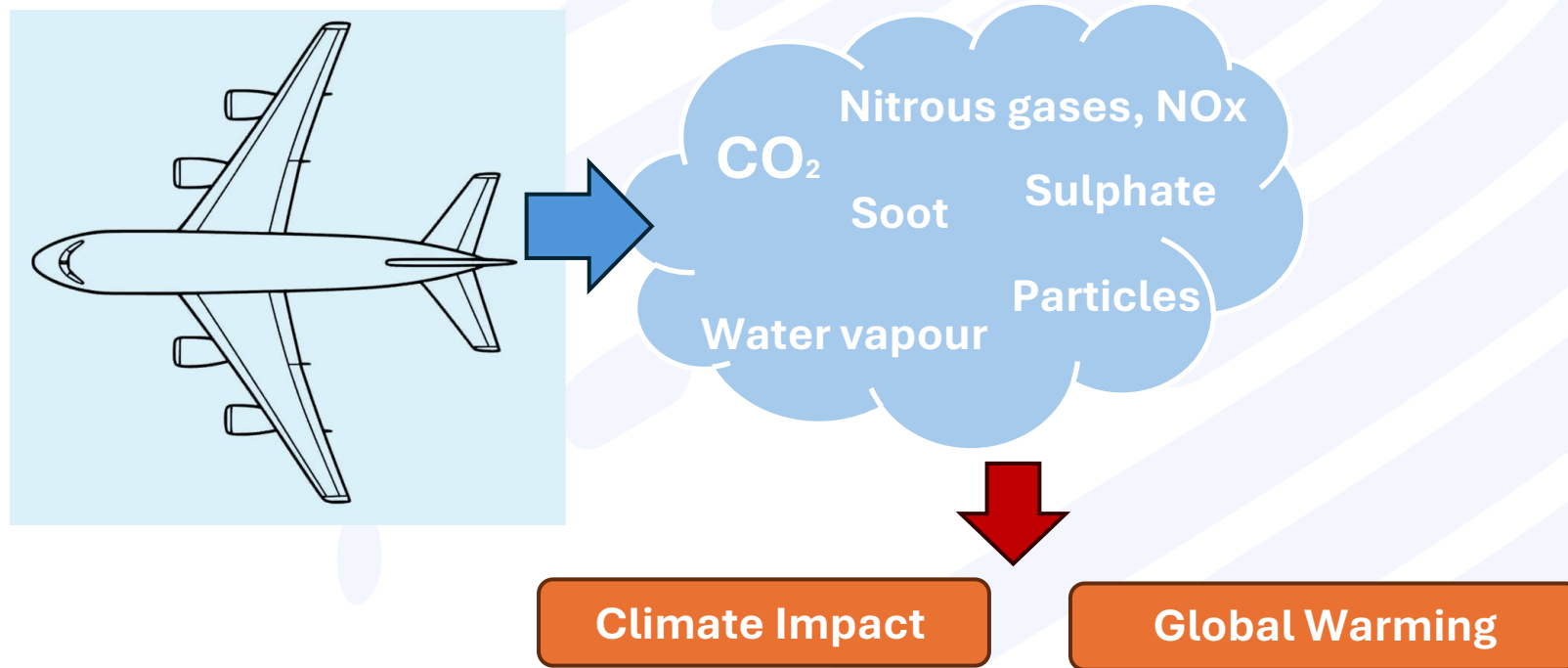
- EXAELIA has as a goal to address the need for **more radical changes in long-range (LR) aircraft** configurations and propulsion concepts to drastically cut the climate impact of long-range flights and to **accelerate the potential entry-into-service** of such aircraft to before 2050.

FLRA needs, requirements and objectives

- Assess stakeholder needs for a sustainable FLRA, focusing on current and future trends – especially sustainability – and define top-level aircraft requirements and indices to guide and assess the design .

➤ Sustainability in the Aviation Sector

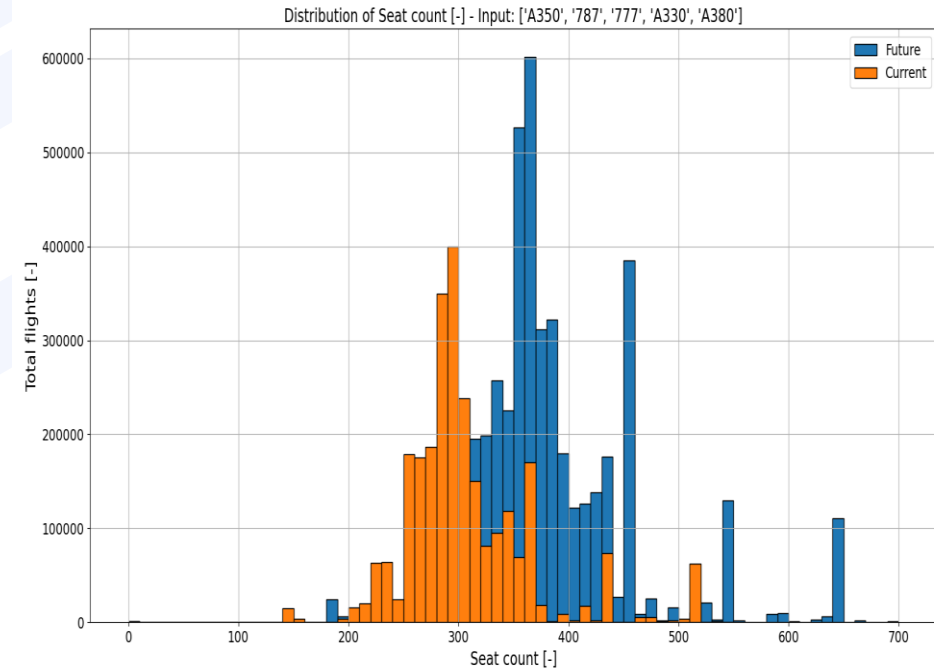
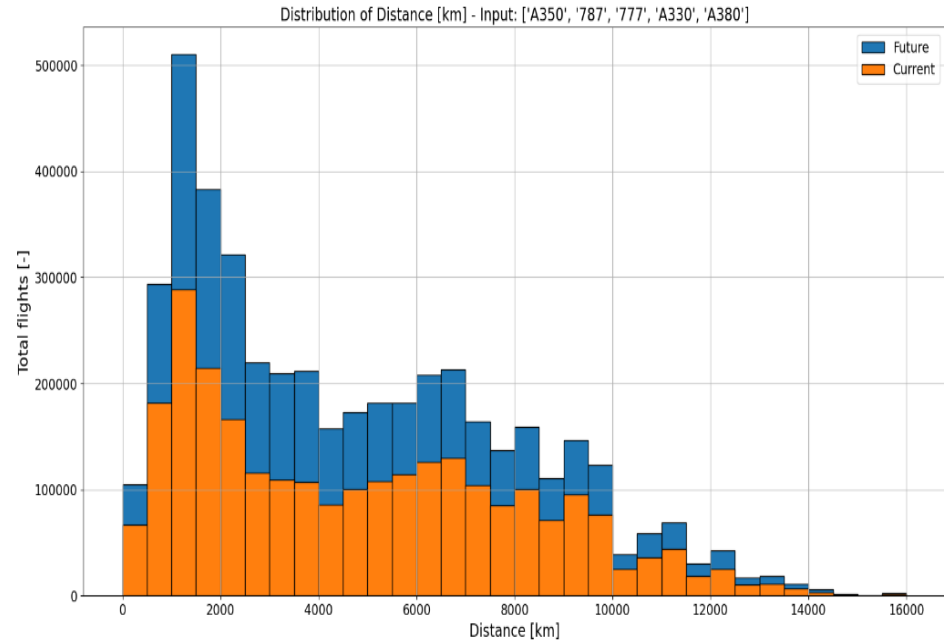
Sustainability focusing only on emissions



- In the aviation sector, sustainability efforts largely center on reducing greenhouse gas emissions and climate impact. This is essential but not sufficient.

Current and Future Worldview

Current and future flown distances and seat count



- The growing demands for air transport drive the need for innovative aircraft designs with **higher efficiency, safety, and sustainability**.
- The challenging requirements of future aircraft make **advanced design approaches** essential for the next generation of aviation.

Sustainability in the Aviation Sector

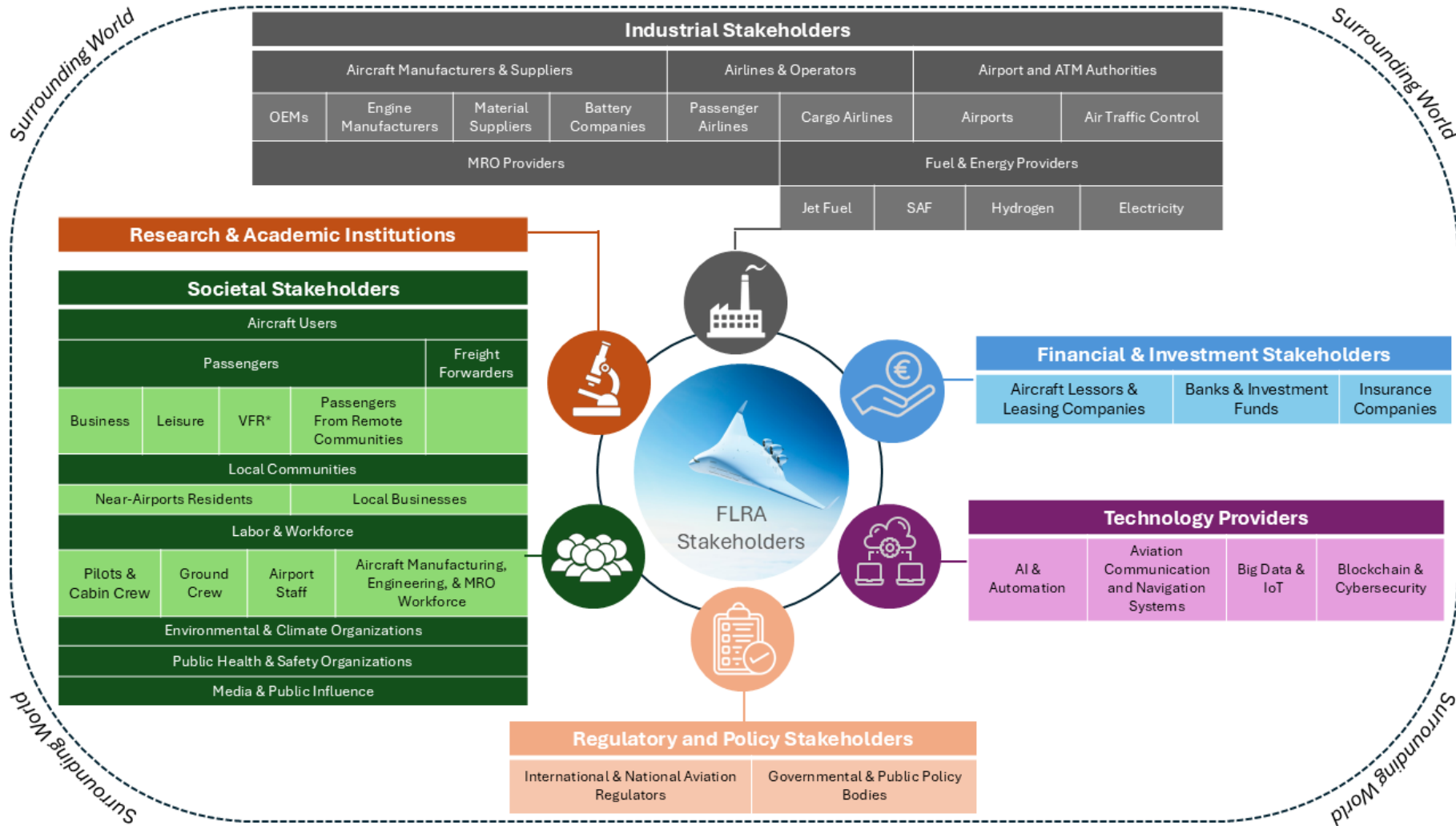
Holistic Sustainability: Sustainability as a 'trade-off'



Current approach

While emissions are critical, sustainability is a complex **balance** involving multiple **interconnected aspects**.

FLRA Stakeholders Identification



Industrial Stakeholders: Aircraft manufacturers, OEMs.

Regulatory & Policy Stakeholders: International and national aviation regulatory authorities (ICAO, EASA, and FAA).

Societal Stakeholders: Organizations which have an interest in the development and operation of the FLRA.

Research & Academic Institutions: Universities, research centres, and academic organizations.

Financial & Investment Stakeholders: Aircraft lessors and leasing companies, banks, investment funds, and insurance companies.

Technology Providers: Companies and organizations.

Identification of Stakeholders' Needs

Extensive **literature review** was performed to identify the FLRA stakeholders' needs:

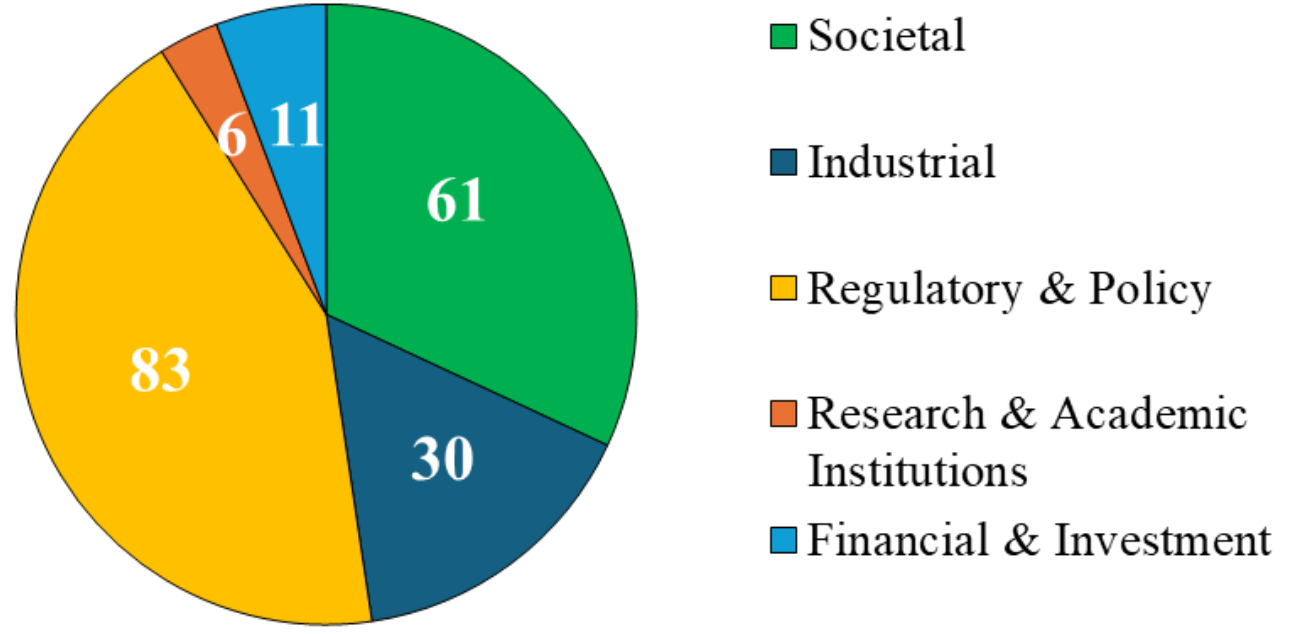
- 70 peer-reviewed journal articles
- 17 technical reports from research and regulatory bodies (e.g. Flightpath 2050, DESTINATION 2050, Fly The Green Deal, ICAO, etc.)
- 17 online sources.



191 distinct stakeholder needs

Distribution of FLRA stakeholder needs :

- 83 Regulatory & Policy
- 61 Societal
- 30 Industrial
- 11 Financial & Investment
- 6 Research & Academic Institutions



Systematic Approach on FLRA Needs and Requirements

Each need is assigned with a **unique ID** to facilitate identification, traceability, and link with the derived requirements

Stakeholder (Main Category)	Stakeholder Sub-categories	Need	Need ID	Aircraft-related System (Yes/No)	References
Societal Stakeholders	Aircraft users > Passengers	Passengers should have access to affordable and reliable long-haul travel options.	N1	No	(Kurtulmuşoğlu, 2016),(Zachariah, 2023)
Societal Stakeholders	Environmental & Climate Organizations (e.g. Greenpeace)	The aircraft design should comply with the growing environmental regulations and sustainability guidelines.	N47	Yes	(CE Delft, 2023), (Greenpeace, 2022)
Industrial Stakeholders	Aircraft Manufacturers & Suppliers> OEMs	The aircraft should cover a distance under nominal operating conditions without refueling.	N62	Yes	(Fröhler, 2023), (Nangia, 2006), (Henderson, 2012)
Industrial Stakeholders	Aircraft Manufacturers & Suppliers> OEMs	The aircraft should maintain an optimal speed during cruise.	N63	Yes	(Fröhler, 2023), (Nangia, 2006), (Henderson, 2012),
Regulatory & Policy Stakeholders	International & National Regulatory & Policy Stakeholders	The aviation industry needs aircraft to achieve a 90% reduction in climate impact from CO ₂ and non-CO ₂ effects compared to 2000.	N130	Yes	(ACARE, 2022)
Regulatory & Policy Stakeholders	International & National Regulatory & Policy Stakeholders	Operators require aircraft operations to cause only 10% of contrails compared to the 2000 baseline by 2050.	N129	Yes	(ACARE, 2022)
Research & Academic Institutions	-	Collaboration between industry and academia should be promoted to secure funding for the development of disruptive aerospace technologies.	N169	No	(NLR), (EASN, 2025), (EASN, 2025)
Financial & Investment Stakeholders	Aircraft lessors and Leasing Companies	Leasing companies seek fuel-efficient and low-maintenance aircraft to attract airline customers.	N172	Yes	(Justin, 2015), (Gibson, 2004)

Needs may overlap!

Systematic Approach on FLRA Needs and Requirements

INCOSE systems engineering methodology is further implemented to determine clear, unambiguous and structured requirements and to ensure a successful design.

Examples

- Id 63: The aircraft shall accommodate passengers with maximum number of TBD while in a standard seating configuration
 - Parent Source: Need N1 (Passengers should have access to affordable and reliable long-haul travel options)
 - Parent Source: Need N40 (The aircraft should accommodate several passengers while ensuring their comfort and safety)
- Id 64: The aircraft shall fly with a non-stop range of minimum TBD km while in nominal operating conditions
 - Parent Source: Need N5 (Flights should be capable of covering long distances in a short time)
 - Parent Source: Need N37 (The aircraft should cover a distance under nominal operating conditions without refueling)
- Id 66: The aircraft shall cruise with speed of maximum TBD Mach while in nominal operating conditions
 - Parent Source: Need N38 (The aircraft should maintain an optimal speed during cruise)

Conclusions & Outlook

- A **sustainability-driven design approach** for FLRA that aligns stakeholder needs with key sustainability considerations throughout the aircraft design process.
- Integration of **sustainability concept from the early design phases** to ensure informed decision-making and long-term benefits.
- Identify and classify relevant **FLRA stakeholders** and their **needs**.
- Implementation of a **systems engineering approach** for the structured derivation of requirements through identified needs.
- The requirements will be derived, along with **key sustainability indices**, to facilitate sustainability assessment throughout the design process.

Thank you!

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