Towards Sustainable Aviation: Addressing Gaps and Future Perspectives in Life Cycle Assessment

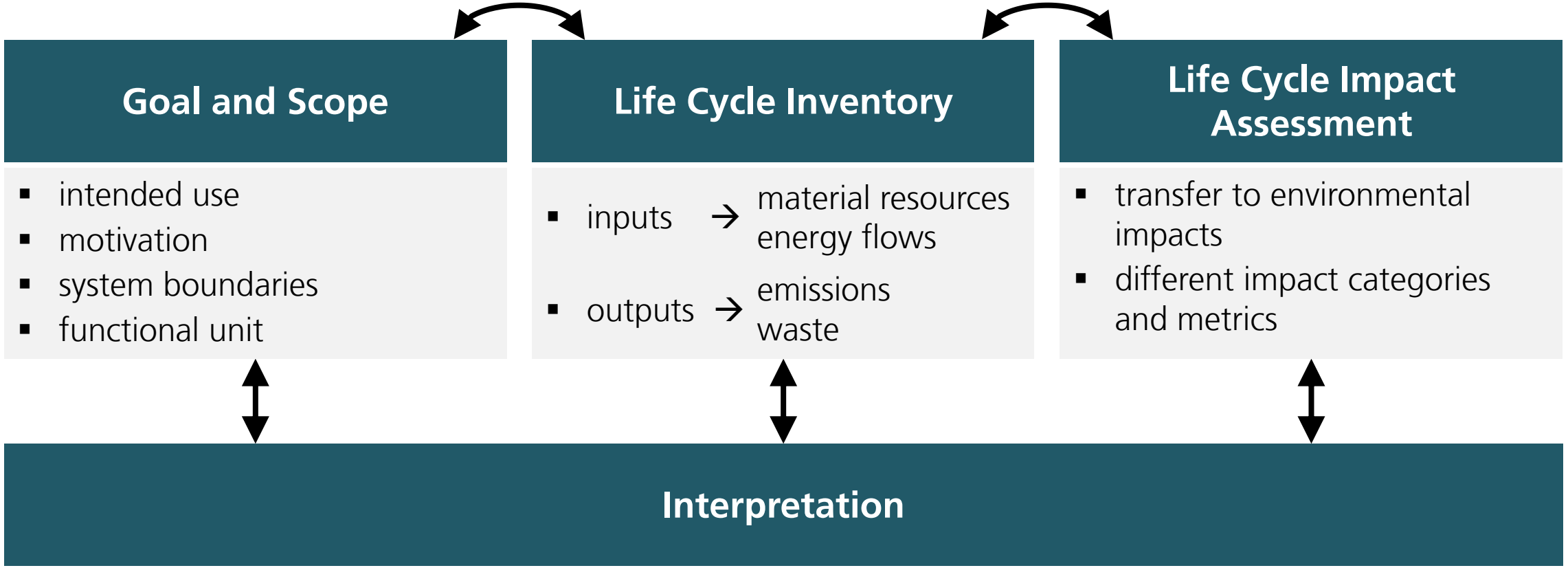
Antonia Rahn, Joana Albano & Kai Wicke
German Aerospace Center (DLR e.V.)
Institute of Maintenance, Repair and Overhaul

Agenda

- Fundamentals of Life Cycle Assessment
- Current Gaps and Challenges
- ALICIA Project
- Take-Aways

Fundamentals
Life Cycle Assessment

"LCA is a tool for examining the total **environmental impact** of a product through **every step** of its **life**"

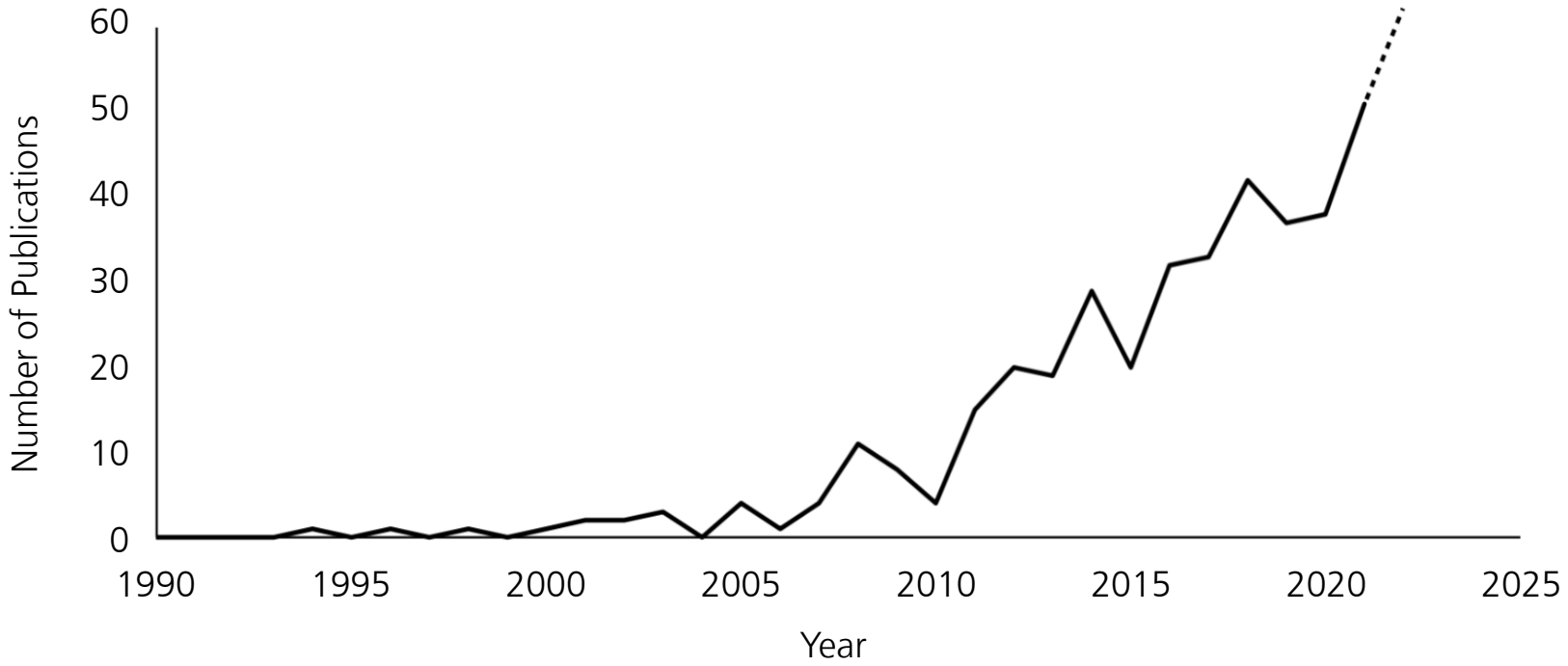


from DIN EN ISO 14040/14044

Fundamentals
Current Research Activities

- topic of life cycle assessment is **gaining in importance**
- number of studies focusing on life cycle assessment in aviation is **increasing** immensely

"life cycle assessment"
AND
"aviation"



Agenda

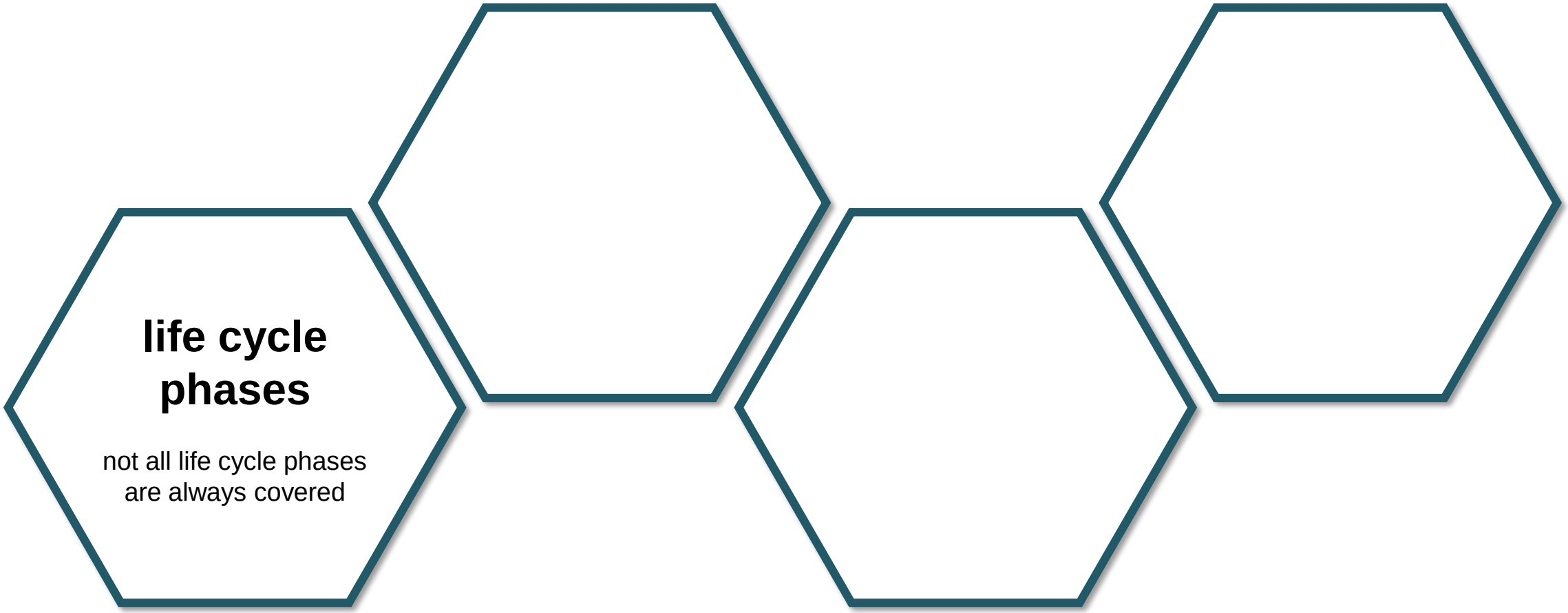
Fundamentals of Life Cycle Assessment

Current Gaps and Challenges

ALICIA Project

Take-Aways

Current Gaps and Challenges



LIFE CYCLE PHASES

Current Gaps and Challenges
Life Cycle Phases

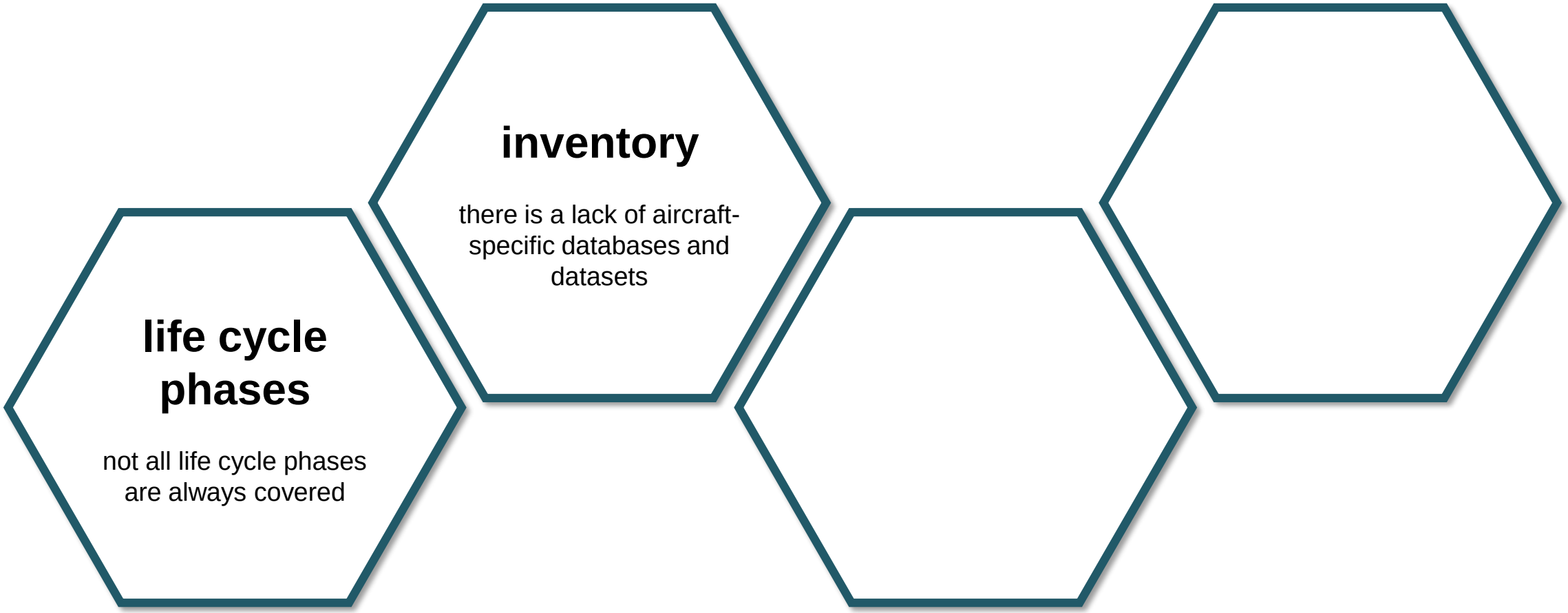
Overview of current LCA studies (extract)

Publication	Study Objective	Manufacturing	Operations	Maintenance	End-of-Life
Façanha et al.(2006)	comparison of different freight transportation modes in the US	●	●	●	●
Chester (2008)	comparison of different transportation modes	●	●	●	○
Lopes (2010)	life cycle assessment of an Airbus A330-200	●	●	●	●
Howe (2011)	life cycle assessment of an Airbus A320	●	●	○	●
Dallara et al. (2013)	comparison of different life cycle assessment approaches and applicabilities	●	●	●	●
Jordão (2013)	life cycle assessment and comparison of an Airbus A330 and a Boeing B777 .	●	●	◑	○
Lewis (2013)	comparison of different flight scenarios (A320, A330 and A380)	●	●	●	○
Howe (2013)	relative environmental impact of each service life phase	●	●	○	●
Kolios (2013)	relative environmental impact of A320 during manufacturing phase	●	○	○	○
Timmis (2014)	life cycle assessment of an all-composite airplane based on a Boeing 787 Dreamliner	●	◑	◑	◑
Jemioło (2015)	life cycle assessment of air transportation	●	●	●	○
Cox (2017-18)	comparison of different transportation modes	●	●	●	◑
Bongo (2020)	life cycle assessment of Airbus A320 and A330 family	○	●	○	○
Fabre (2022)	life cycle assessment of aircraft similar to an Airbus A320	●	●	◑	○

● included; ◑ partially included; ○ not included

- most studies focus on **manufacturing** of aircraft components and **different fuel types**
- maintenance and end-of-life is **often simplified** or **neglected**

Current Gaps and Challenges



Current Gaps and Challenges
Inventory

"The [aircraft production] process [...] do not exist on the database, but have been created based on the car production process." (Fabre et al., 2022)

"The inventory data for carbon fiber manufacturing [for aircraft] are not well defined in any LCI database." (Calado et al., 2019)

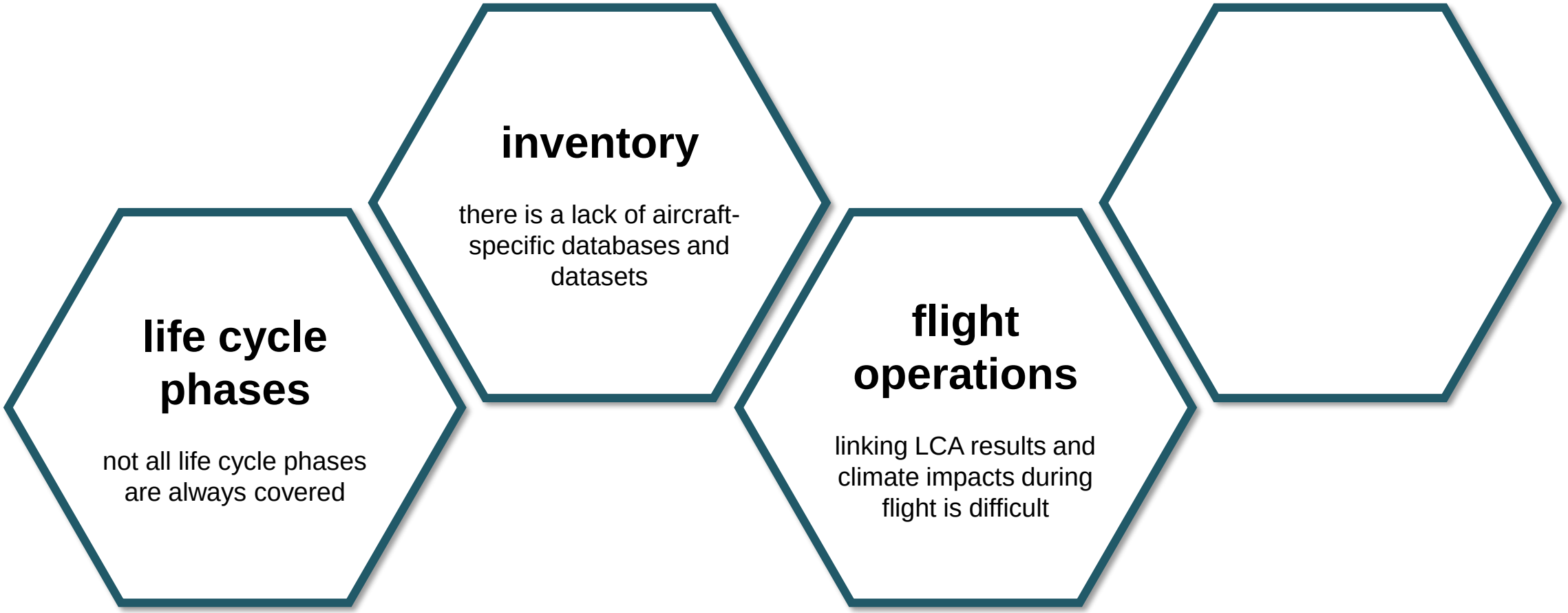
"CFRP and aviation biofuel material processes are currently not available in the leading LCI database packages." (Howe et al., 2013)

"Existing life cycle inventory (LCI) databases [...] do not cover aircraft maintenance." (Rupcic et al., 2023)

and many more...

Fabre et al., 2022 (doi: 10.2514/6.2022-1028)
Calado et al., 2019 (doi: 10.1007/s11367-019-01632-8)
Howe et al., 2013 (doi: 10.1016/j.trd.2012.12.004)
Rupcic et al., 2023 (doi: 103717. 10.1016/j.trd.2023.103717)

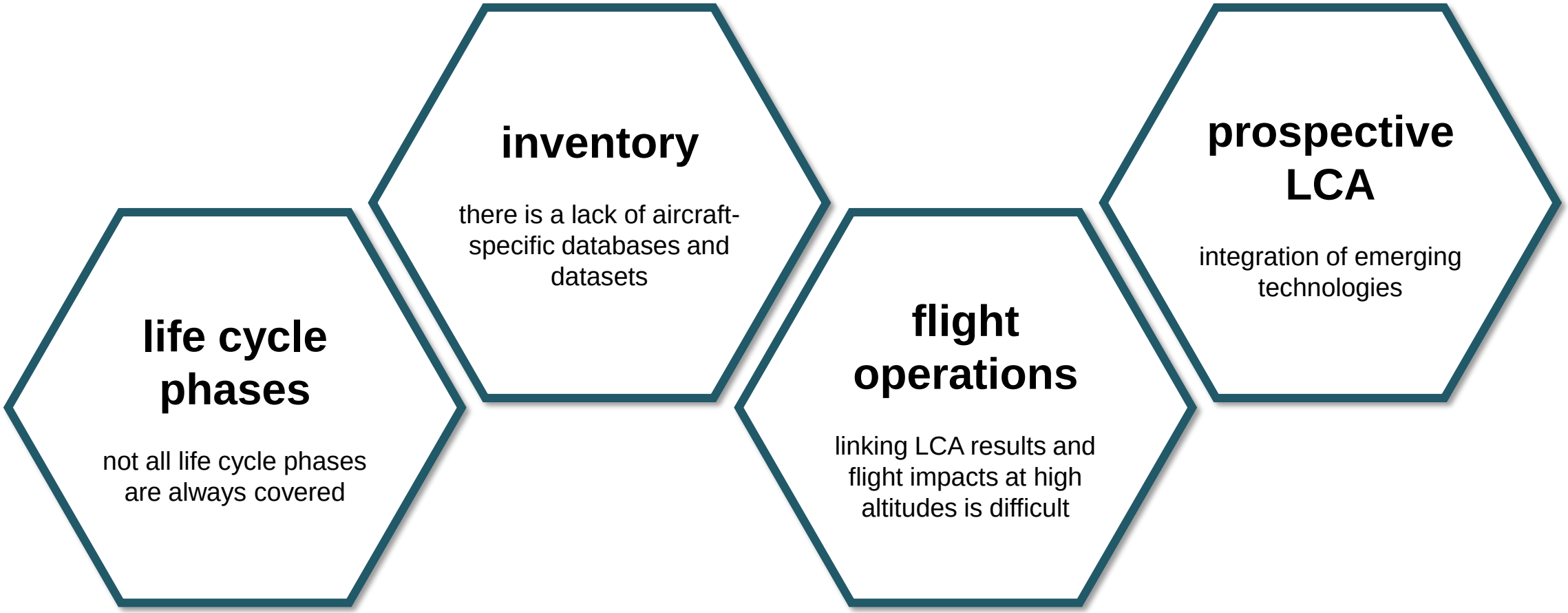
Current Gaps and Challenges



Current Gaps and Challenges
Climate Impact during Flight Operations

- different metrics
- uncertainties in modeling
- interactions among pollutants and emissions
- long-term effects

Current Gaps and Challenges



Agenda

Fundamentals of Life Cycle Assessment

Current Gaps and Challenges

ALICIA Project

Take-Aways

ALICIA Project
Overview

ALICIA
Aviation Life Cycle and Impact Assessment

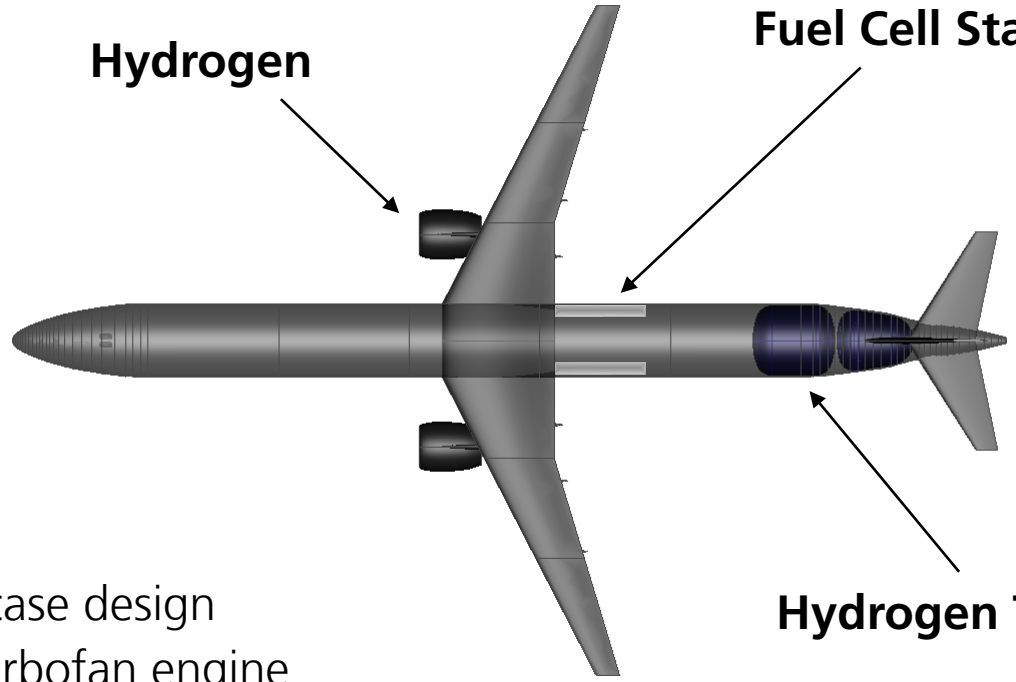
Objectives

- establishment of an aircraft-specific database
- life cycle assessment coupling with (climate) impact assessment
- creation of an automatic framework and dashboard

ALICIA Project
Use Case

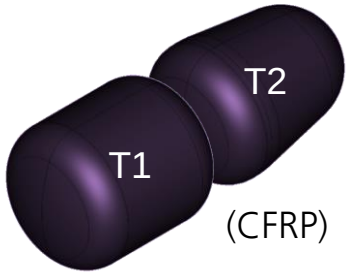
comparison of conventional and hybrid-electric aircraft

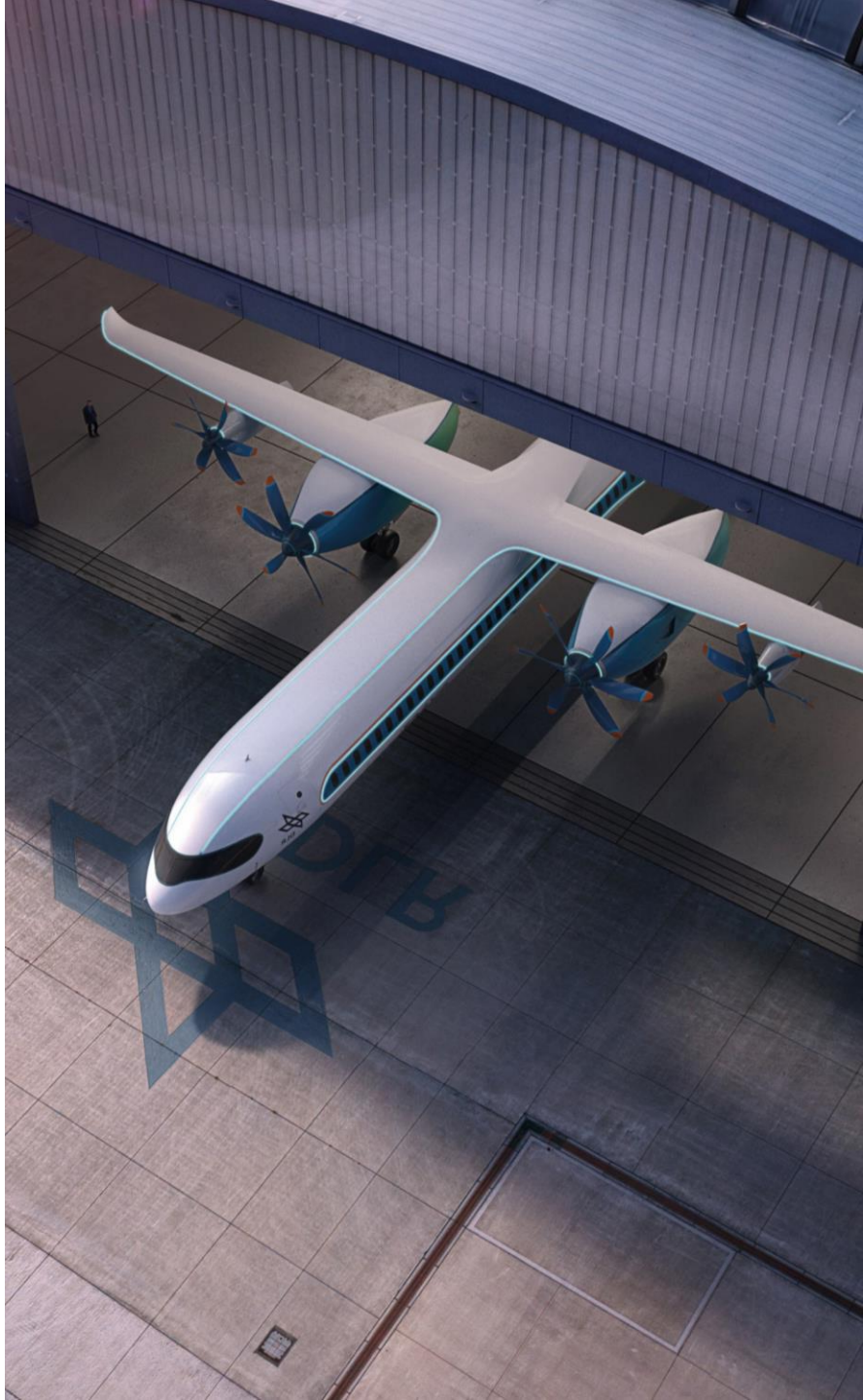
- powered with Jet A-1, SAF, and hydrogen



use case design

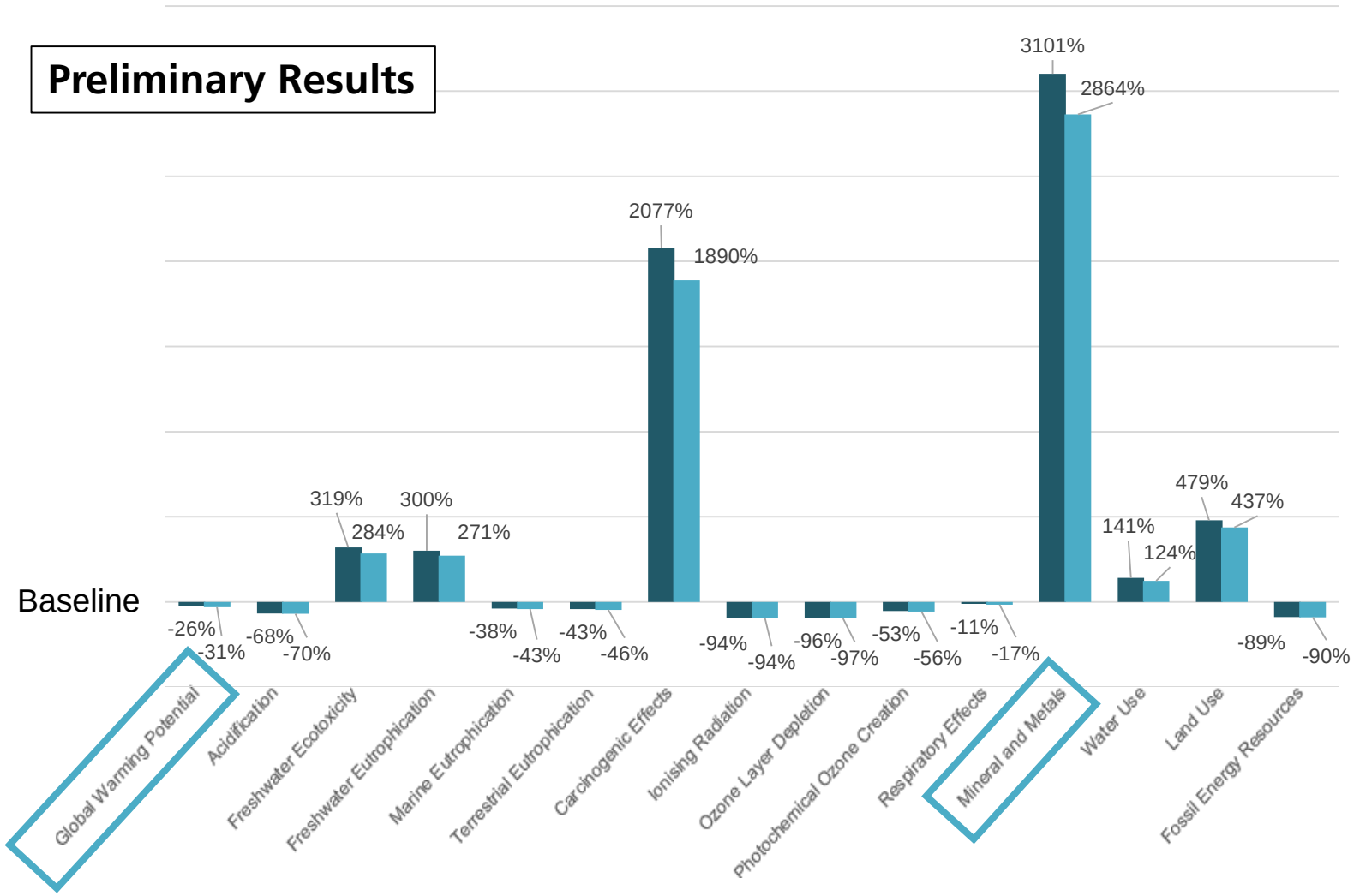
- turbofan engine
- 250 PAX
- entry-into-service 2040





ALICIA Project
Use Case

Preliminary Results



Baseline – **Jet A-1**

Baseline – **SAF**

Hybrid-Electric Aircraft – **H2**

*aircraft design from DLR-internal project

Agenda

Fundamentals of Life Cycle Assessment

Current Gaps and Challenges

ALICIA Project

Take-Aways

Take-Aways
Life Cycle Assessment in Aviation

Take-Aways

- environmental life cycle assessment is crucial for sustainable developments in aviation
- the amount of studies focusing on this issue is increasing immensely
- however, there are still challenges and gaps to overcome
- the German Aerospace Center (DLR e.V.) is addressing these gaps

Antonia Rahn
antonia.rahn@dlr.de

ALICIA News

THANK YOU!