H2Avia - Hydrogen in Aviation – LuFoVI.2

THE H2AVIA PROJECT - GOALS AND AIRCRAFT SYNTHESIS STRATEGY

EASN CONFERENCE THESSALONIKI, GREECE 10TH OCTOBER 2024

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DOI: 10.5281/zenodo.13919687

Content

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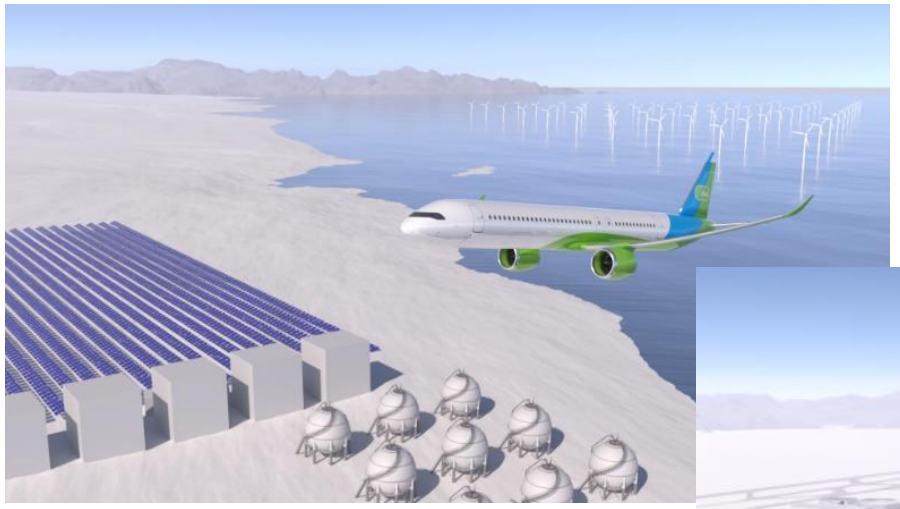
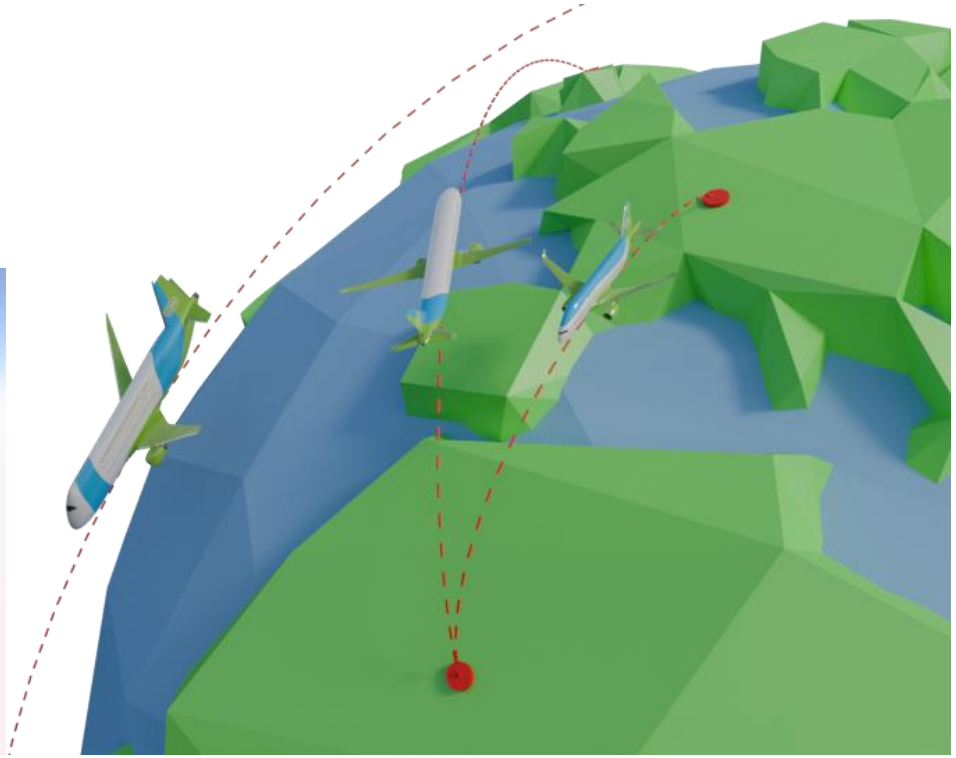
Goals

H2Avia analyses hydrogen's aviation potential from fuel production, aircraft integration to global fleet carbon footprint.





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Goals → KPIs

- Quantify the **contribution that H2 as the main energy** source in aviation can make to achieve the ***climate targets***.
- Determine the ***cost and climate impact*** **of H2 production and transport** and its use in airport ground operations.
- Identification and **modelling of critical technologies** required for the introduction of H2 in civil transport aircraft (***weight, power, drag***)
- Modelling of **relevant aircraft classes performance** (***block energy***)
- Apply a global fleet model and life cycle assessment for a **holistic scenario** evaluation (***atmospheric temperature response***)

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H2Avia Goals

Project Structure

Aircraft Synthesis Strategy

Outlook

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Project Structure

WP1: H2 Provision & Infrastructure	WP2: Technological blocks in aircraft	WP3: Evaluation of the overall aircraft concept	WP4: Overall balance of hydrogen in aviation
T1.1: H2 Production and transport	T2.1: Identification of relevant & open technology blocks	T3.1: Technology selection for the aircraft configurations	T4.1: Demand estimation & fleet
T1.2: H2 Logistics	T2.2: Propulsion	T3.2: Overall aircraft design for different classes	T4.2: Investigation of non-CO_2 effects
	T2.3: H2-supply system in the aircraft	T3.3: Concept assessment & technology roadmap	T4.3: H2 aviation system LCA
	T2.4: Fuselage		T4.4: Overall assessment of H2 in aviation
	T2.5: Wing		

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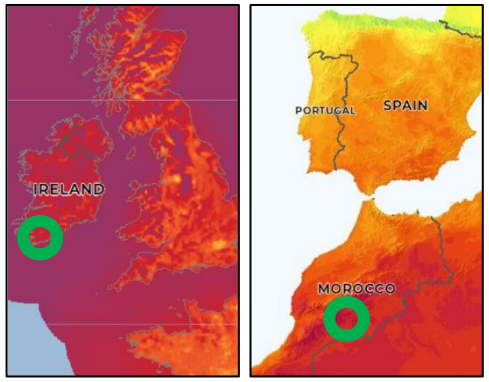
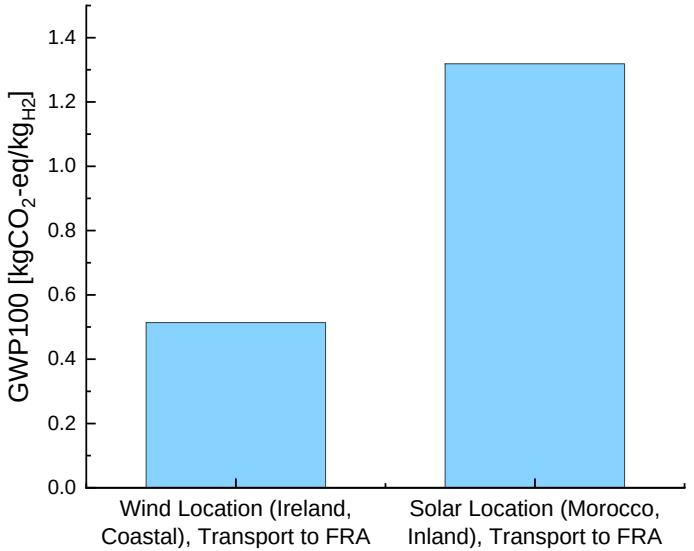
WP1 results

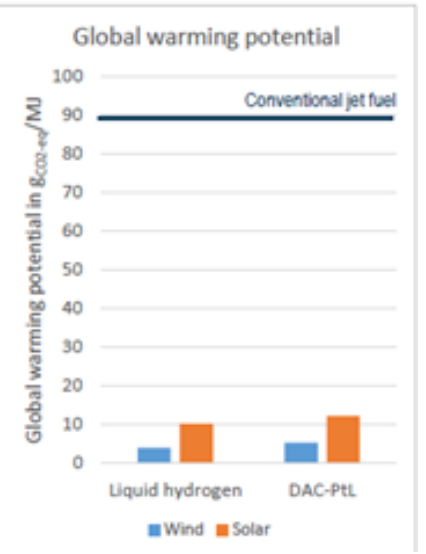
WP1:
H2 Provision & Infrastructure

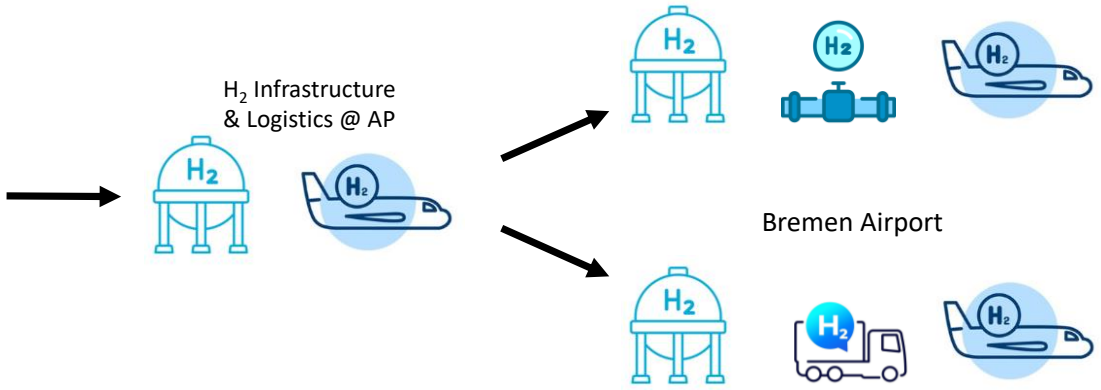
T1.1: H2 Production and transport

T1.2: H2 Logistics









N. of aircrafts	504
Assumed LH_2 required	2.127 t/day
N. of LH_2 tanks	8
Lenght of the pipeline	1500 m
N. of pipelines	5

N. of aircrafts	15
Assumed LH_2 required	34 t/day
N. of LH_2 tanks	1
N. of trucks	3
Meters of truck drive	1800 m

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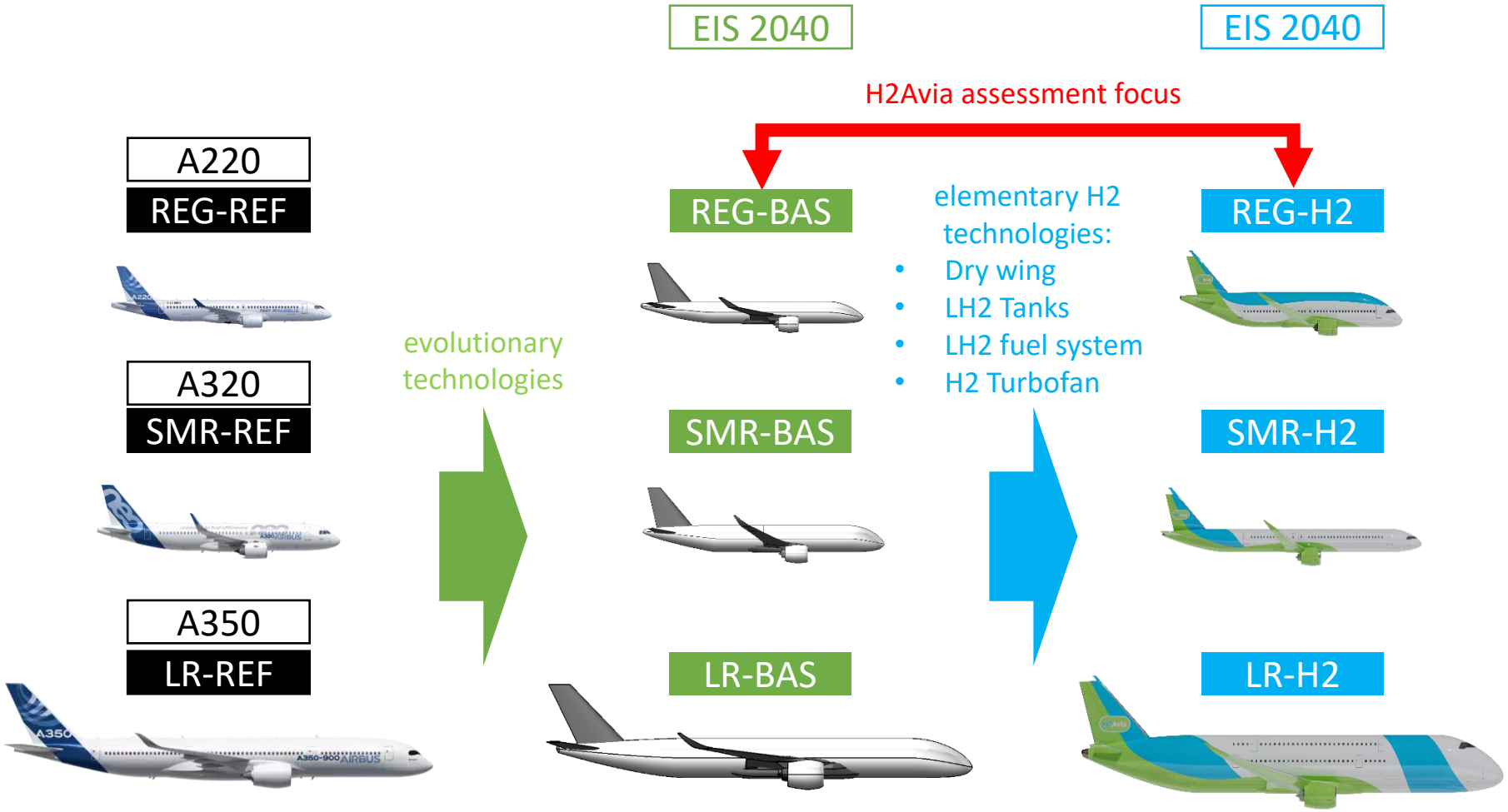
Technology Assessment



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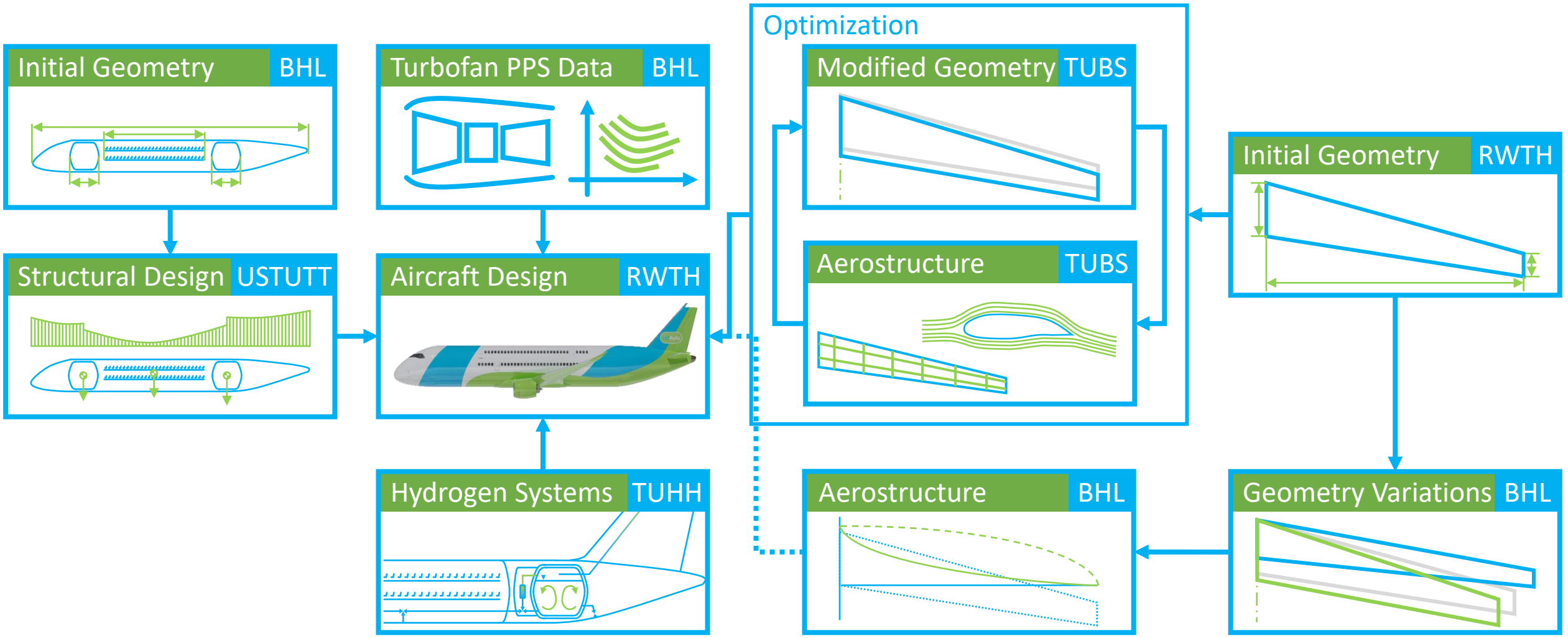
Aircraft Synthesis Strategy



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Tank Configuration Down-Selection

- The objective of the H2Avia tank configuration down-selection workshop was to identify **most promising tank configurations**
- Application of a 5 step approach:
  1. Compilation of configuration **design space**
  2. Definition of a comprehensive set of qualitative multi-disciplinary **criteria**
  3. **Pre-selection** based on preliminary partner input
  4. **Down-selection** by candidate configurations rating against the criteria that have been tailored to appropriately resolve candidate-specific differences
  5. Robustness of rating decisions was gauged through systematic **permutations of criteria weightings** (scenarios)

Down selection procedure based on:

- A. Seitz, M. Nickl, A. Stroh, and P. C. Vratny, "Conceptual Study of a Mechanically Integrated Parallel-Hybrid Electric Turbofan," in *7th EASN International Conference*, Warsaw, Poland, 2017.
- A. T. Isikveren *et al.,* "Distributed propulsion and ultra-high by-pass rotor study at aircraft level," *The Aeronautical Journal*, vol. 119, no. 1221, pp. 1327–1376, 2015, doi: 10.1017/S0001924000011295.
- F. Mistree, K. Lewis, and L. Stonis, "Selection in the conceptual design of aircraft," in *5th Symposium on Multidisciplinary Analysis and Optimization*, Panama City Beach, FL, U.S.A, 1994.

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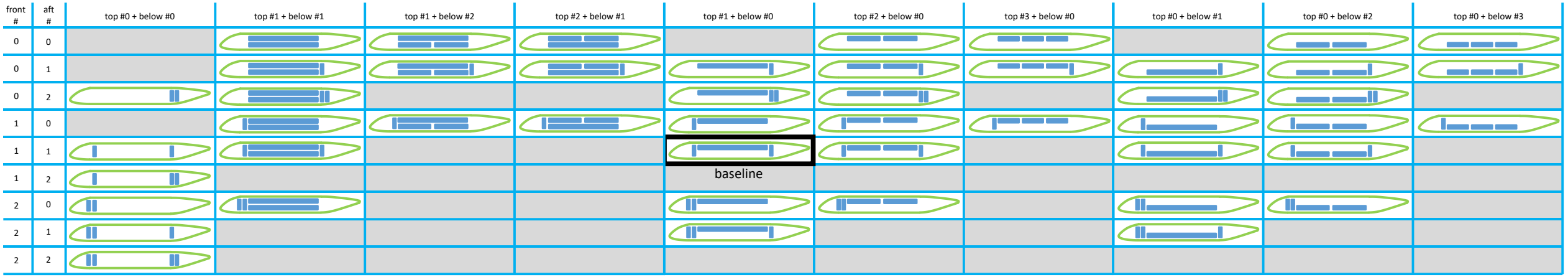
Tank Configuration Design Space

The complete tank configuration design space included these principles

- 4 types of tanks: front (of cabin), aft, top and below
- Minimum 2 tank, Maximum 4 tanks
- no more than 2 tanks front or aft, 3 for top or bottom



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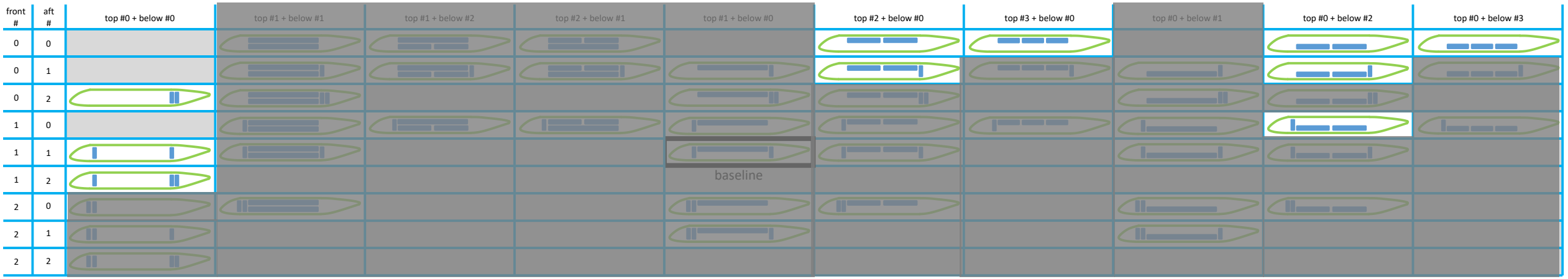
Tank Configuration Pre-Selection

The following common aspects were deducted from the partner input:

- Combination of top and bottom tanks are ruled out
- Maximum number of tanks: 3
- No single top/bottom tank (disc burst corridor → bad CoG control + no bump)
- only 1 front, no catwalk (weight penalty); expected: autonomous/single pilot



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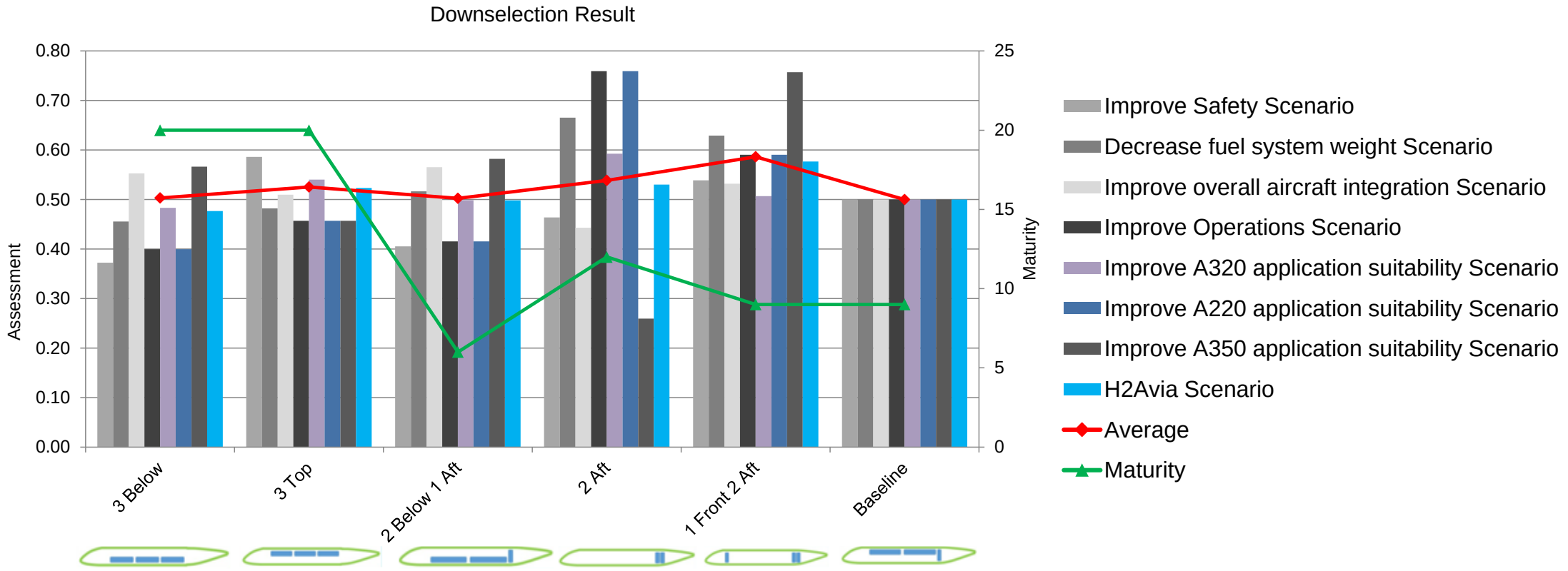
Down Selection Scenario Results



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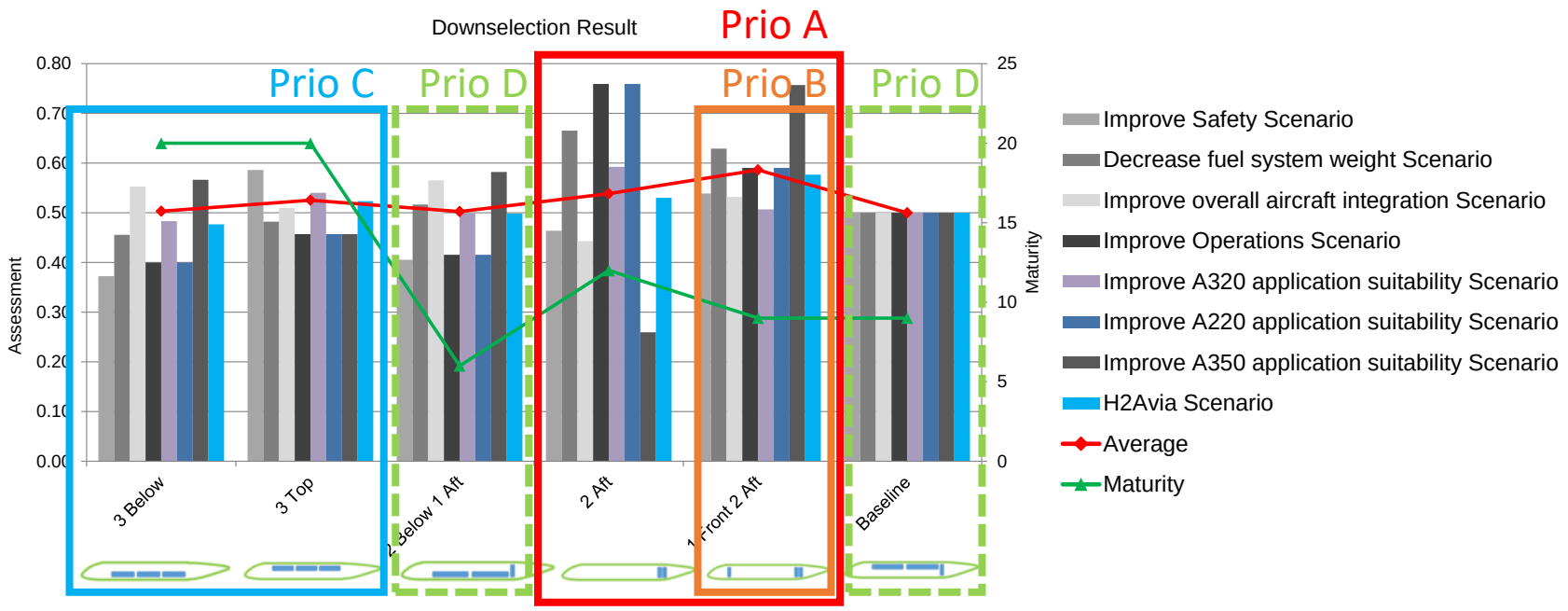
Selected configurations prioritization

- Priority A:
  - A220: F0A2T0B0
    AC specific points
    + H2Avia Scenario
  - A320: F0A2T0B0
    AC specific points
    + H2Avia Scenario
  - A350: F1A2T0B0
    AC specific points
    + H2Avia Scenario



- Priority B: Common configuration for all: 1 Front 2 Aft (highest average)
- Priority C: Analyze isolated effect of 3 Below and 3 Top
- Priority D: F0A1X2 → Possible best synergy; Prio C results → top or bottom

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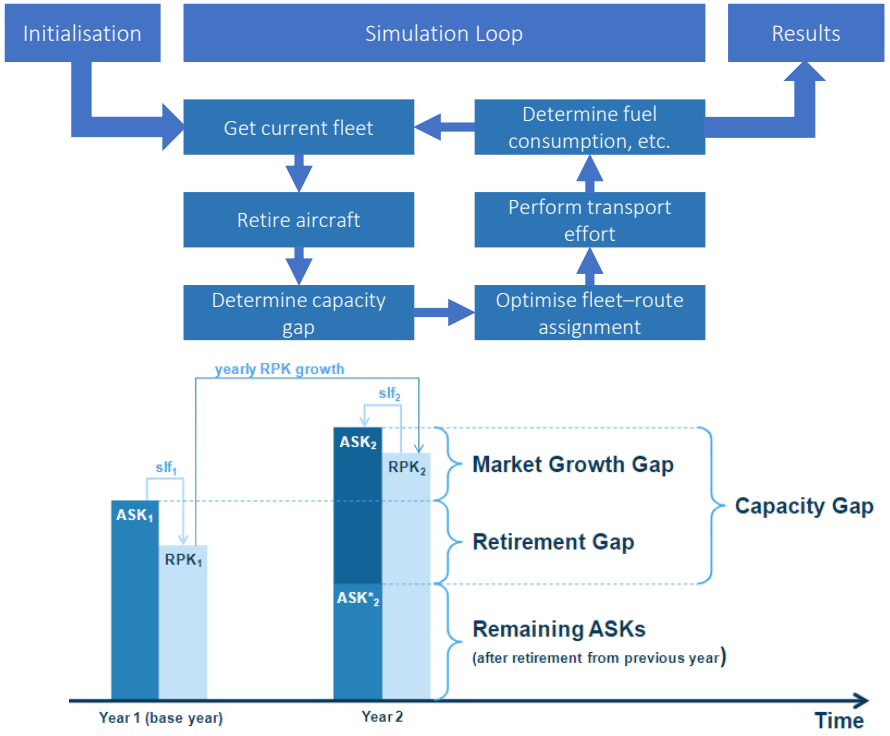
Demand estimation & fleet



6 Regions

- Europe (EU)
- North America (NA)
- Latin America (LA)
- Africa (AF)
- Middle East (ME)
- Asia (AS)

21 Routes

EU Domestic, EU-NA, EU-LA, EU-AF, EU-ME, EU-AS, NA Domestic, NA-LA, NA-AF, NA-ME, NA-AS, LA Domestic, LA-AF, LA-ME, LA-AS, AF Domestic, AF-ME, AF-AS, ME Domestic, ME-AS, AS Domestic

Time Horizon

2018 – 2070

CAGR

By region pair

Global ~3.6%

Optimization strategy

MIN(Climate Impact)

WP4: Overall balance of hydrogen in aviation

T4.1: Demand estimation & fleet

T4.2: Investigation of non-CO_2 effects

T4.3: H2 aviation system LCA

T4.4: Overall assessment of H2 in aviation

- Randt, Niclas Peter (2016): Aircraft technology assessment using fleet-level metrics. Online verfügbar unter https://mediatum.ub.tum.de/1277838.
- Oguntona, Oluwaferanmi: Aircraft Fleet Renewal: Assessing Measures for Reducing CO2 Emissions. Technische Universität München. Online verfügbar unter https://mediatum.ub.tum.de/1506509.
- MINIMAL Project Report

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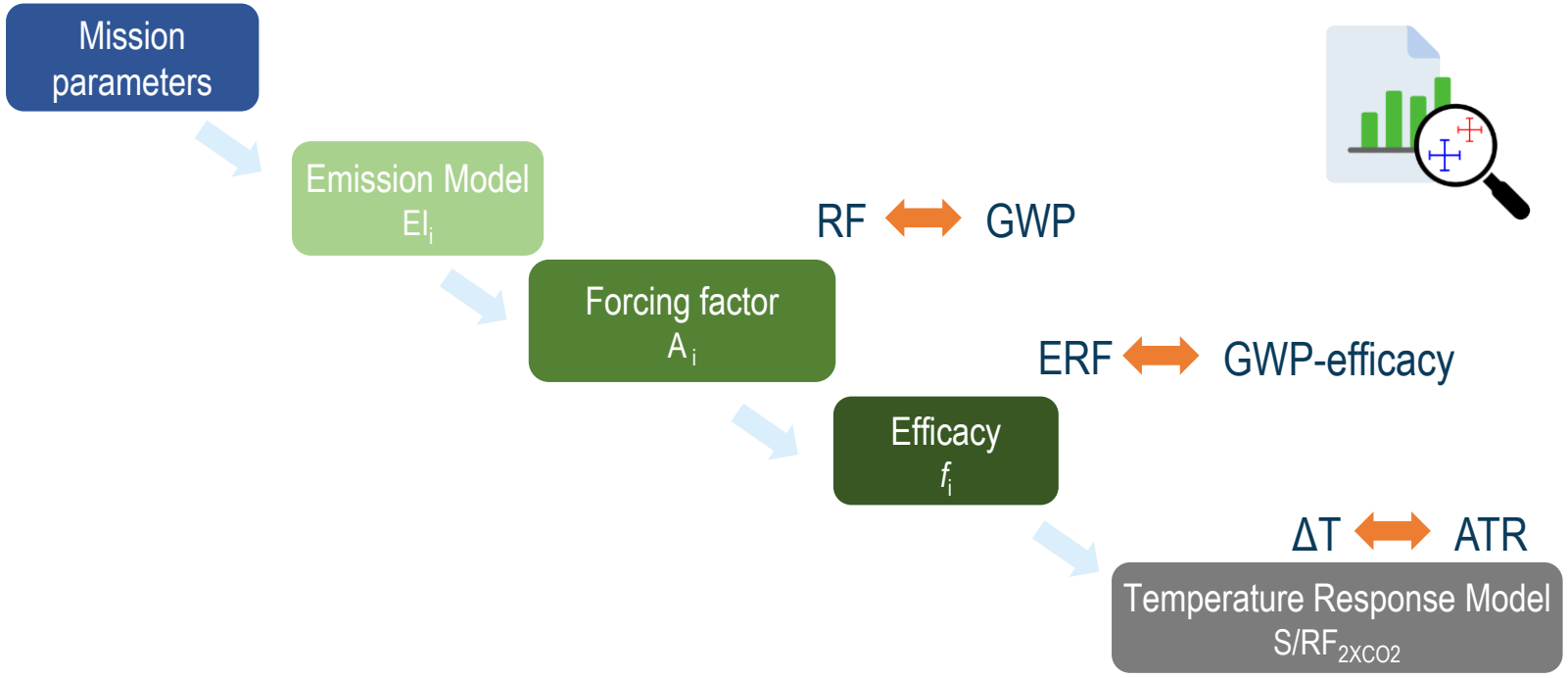
Investigation of non-CO2 effects



WP4: Overall balance of hydrogen in aviation

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- **T4.2: Investigation of non-CO_2 effects**
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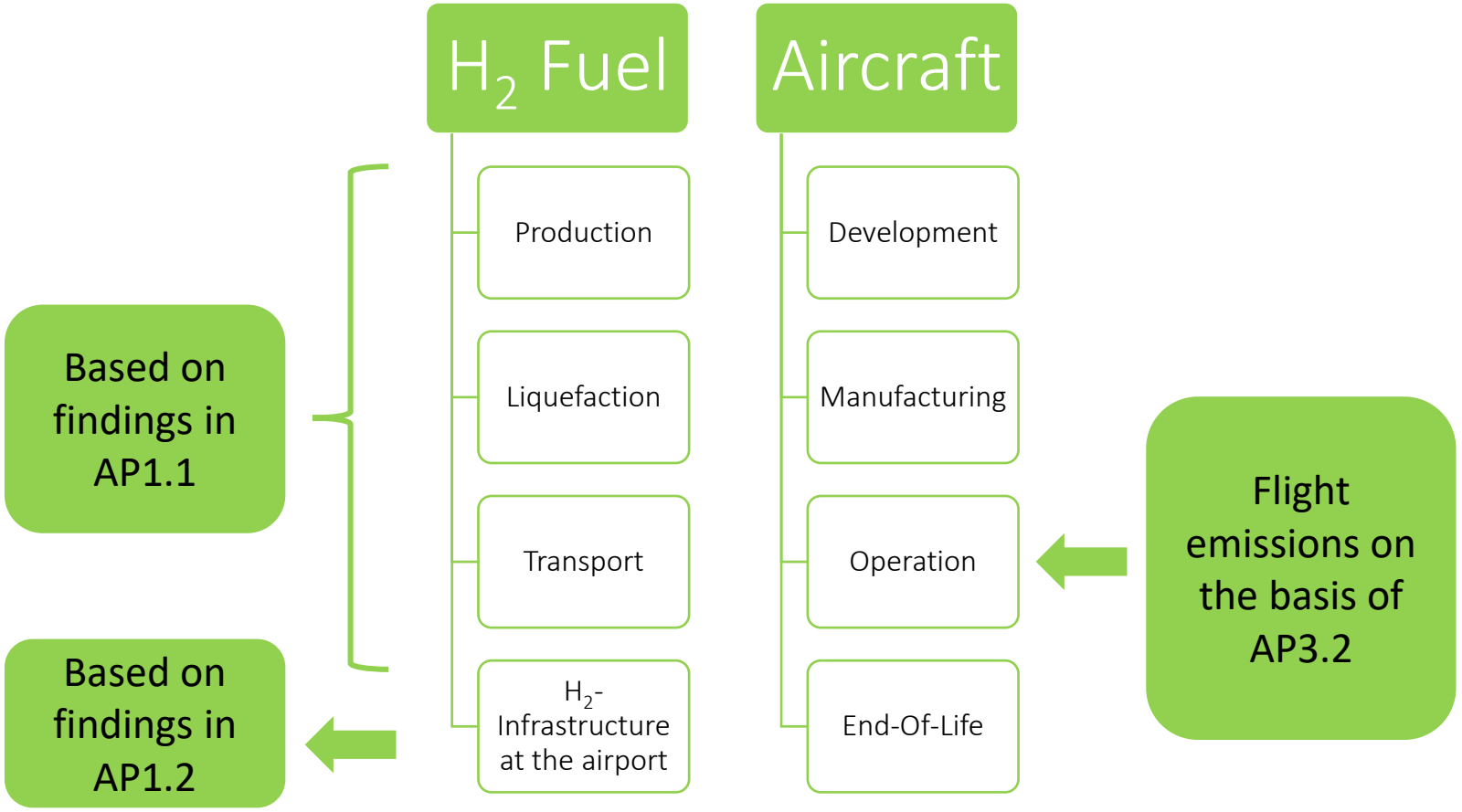
H2 aviation system LCA



WP4: Overall balance of hydrogen in aviation

- T4.1: Demand estimation & fleet
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- **T4.3: H2 aviation system LCA**
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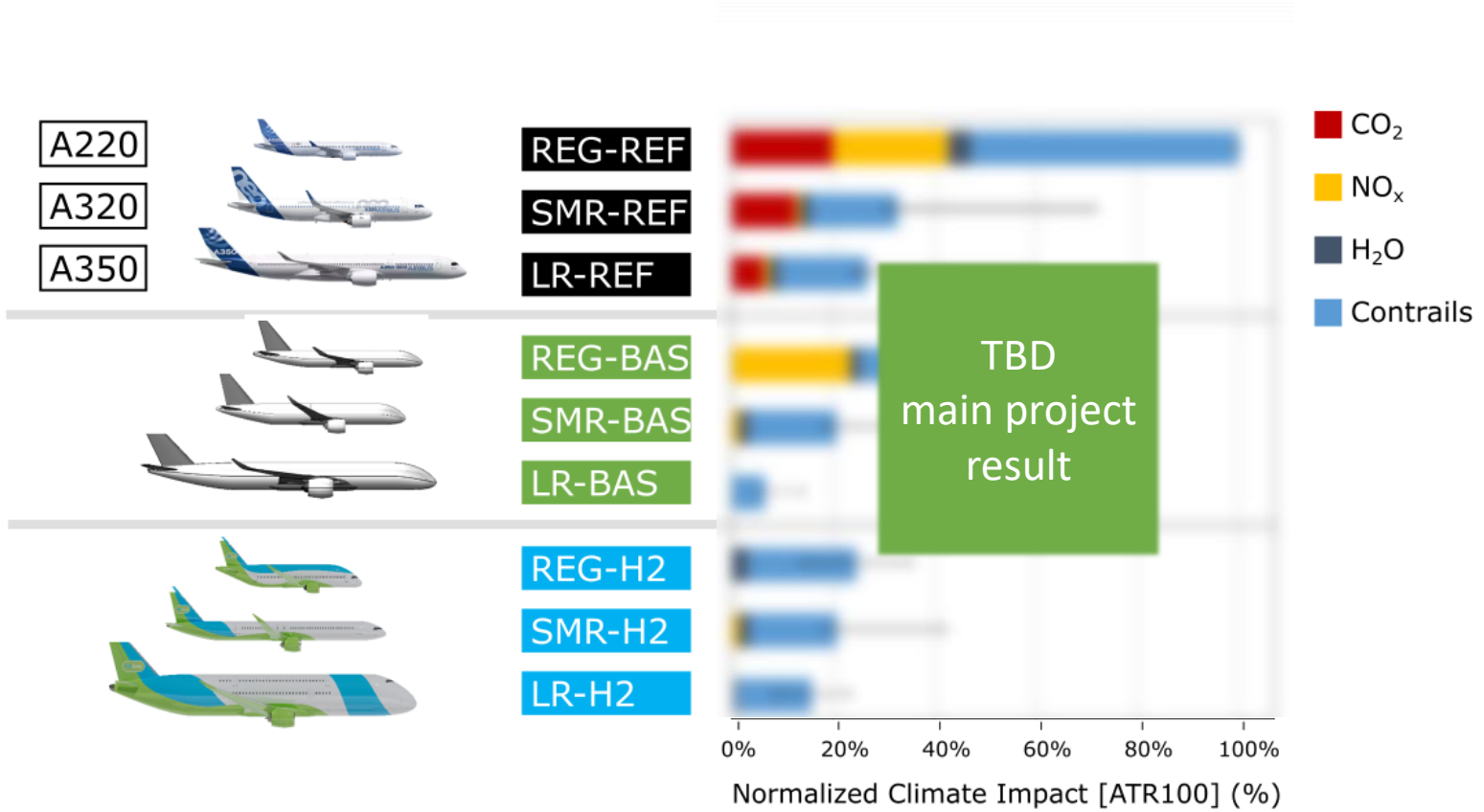
Overall assessment of H2 in aviation



WP4:
Overall balance of hydrogen in aviation

- T4.1: Demand estimation & fleet
- T4.2: Investigation of non-CO_2 effects
- T4.3: H2 aviation system LCA
- **T4.4: Overall assessment of H2 in aviation**

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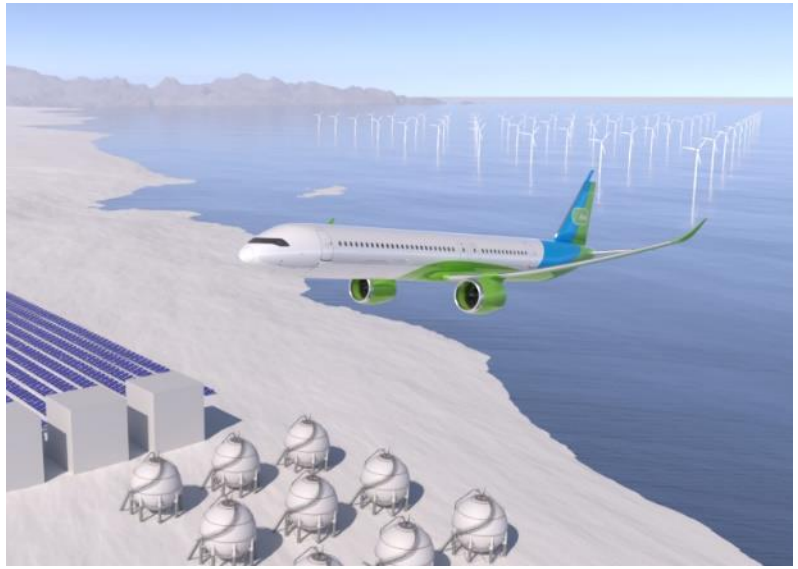
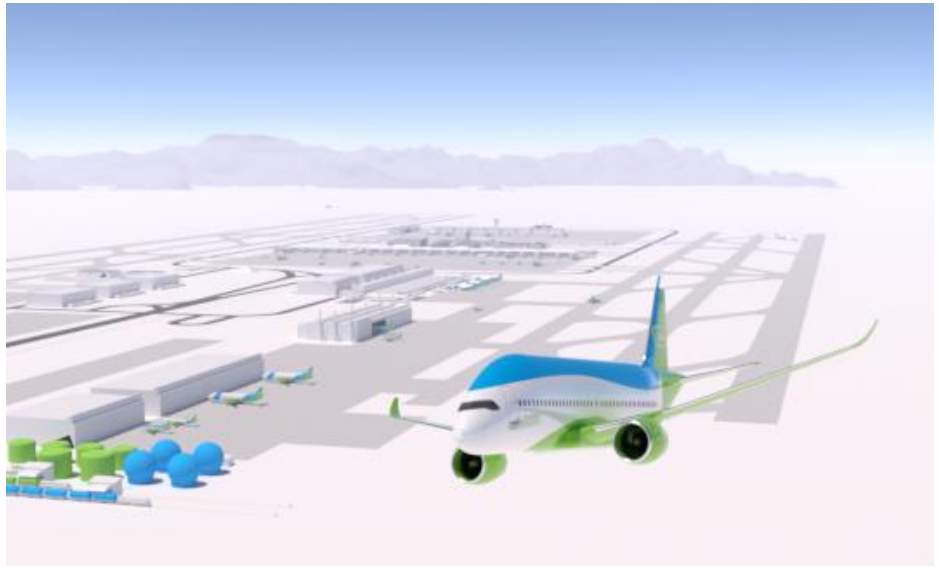
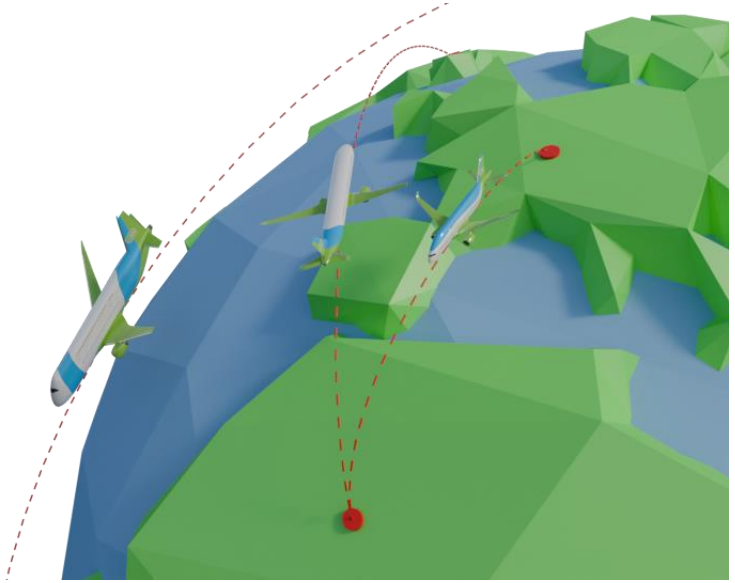
Conclusion

H2Avia is on track to provide an analyses of hydrogen's aviation potential from fuel production, aircraft integration to global fleet carbon footprint. Follow us on LinkedIn!







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Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

H2Avia is a project of the federal funded aviation research program (LuFo) VI-2
FKZ 20E2106

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