D3.2 – Advanced/Disruptive Aircraft Concepts and Architectures, Purpose-Built Research Infrastructures, and Advanced Aeronautical Research and Technology

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Abstract

The first part of the report provides an overview of recent developments in advanced and disruptive aircraft concepts, focusing on their environmental performance improvements. The concepts are categorised according to various aspects such as aircraft architecture, fuel/energy, propulsion technology, aerodynamics, and structure. The study reveals trends and patterns in the development of these concepts, with a range of technologies showing promise for reducing emissions and environmental impact. Overall, the report highlights the potential for significant environmental performance improvements in the aviation sector, with some concepts achieving substantial reductions in fuel burn and emissions.

The second part aims to describe the research facilities and test aircraft (including research gaps) as well as relevant aeronautical research activities and technology areas in the shortlist per topic, including the extent to which these contribute to the R&I in aircraft concepts, architectures and technologies for reducing greenhouse-gas emissions. First, the literature review is described, as well as the recent and on-going research programmes related to such concepts and architectures. Additionally, the advanced and purpose-built research facilities or test aircraft available on a global scale are described, as well as a compilation of relevant aeronautical research activities and technology areas including potential synergies with other sectors.

Keywords

Clean Aviation, Advanced aircraft concepts, Disruptive aircraft concepts, Aircraft architectures, Research infrastructure, Aeronautical Research, Innovative Technologies

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Information Table

Contract Number	**101140632**
Project Title	Clean Aviation Support for Impact Monitoring
Topic	HORIZON-JU-CLEAN-AVIATION-2023-02-CSA-01
Type of Action	HORIZON JU Coordination and Support Actions
Project Start Date	2024-01-01
Duration	18 Months
Project Coordinator	Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)
Deliverable Number	D3.2
Deliverable Title	Advanced/disruptive aircraft concepts and architectures, purpose-built research infrastructures, and advanced aeronautical research and technology
Version	1.0
Status	Final
Responsible Partner	NLR
Deliverable Type	Report
Contractual Date of Delivery	2024-12-31
Actual Date of Delivery	2025-02-21
Dissemination Level	PU

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Document history

Version	Date	Status	Author	Description
0.1	02.12.2024	Document created	Lukas Söffing	
0.2	20.12.2024	Draft for review	Lukas Söffing Elise Scheers Mario A. Solazzo Veronica Villani Lidia Travascio	
1.0	21.02.2025	Final document	Lukas Söffing Elise Scheers Mario A. Solazzo Veronica Villani Lidia Travascio	

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Table of Acronyms and Abbreviations

Acronym/Abbreviation	Description / Meaning
ACARE	Advisory Council for Aviation Research and Innovation
ACTE	Adaptive compliant trailing edge
Arch	Architecture
ATI	Aerospace Technology Institute UK
ATM	Air traffic management
ATR	Average Temperature Response
BLI	Boundary layer ingestion
BWB	Blended wing body
CA	Clean Aviation
CDO	Continuous Descent Operations
CIRA	Italian Aerospace Research Centre
CLAIM	Clean Aviation support for Impact Monitoring
CS1, 2	Clean Sky 1 and 2
CO_2	Carbon dioxide
CTA	Controlled Time of Arrival
DEP	Distributed electric propulsion
DLR	German Aerospace Centre
EASA	European Union Aviation Safety Agency
EC	European Commission
eCTOL	electric Conventional Take-Off and Landing
EIS	Entry into service
EU	European Union
eVTOL	electric Vertical Take-Off and Landing
FAA	Federal Aviation Administration US
FP7	7^{th} Framework Programme for Research
GE	General Electric
GTF	Geared turbofan
GTP	Global temperature potential
GWP	Global warming potential
H_2	Hydrogen
H2020	Horizon 2020
H2Av	Hydrogen for Aviation
HE	Hybrid-Electric
HE	Horizon Europe
HE/CR	Horizon Europe/Collaborative Research
HER	Hybrid-electric regional
HERA	Hybrid Electric Regional Aircraft
IM	Impact Monitor
JAXA	Japan Aerospace Exploration Agency
JU	Joint Undertaking
LNG	Liquid natural gas
LTO	Landing and take-off
MorE	More Electric

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MTM	Mission Trajectories Management
N/A	Not Available
NASA	National Aeronautics and Space Administration US
NLR	Netherlands Aerospace Centre
Nm	Nautical miles
NO_X	Nitrogen oxides
OEM	Original Equipment Manufacturer
ONERA	French national office for aerospace studies and research
OTM	Optimised Traffic Management
PAX	Passenger
PU	Public
R&I	Research & Innovation
Ref.	Reference
SAF	Sustainable aviation fuel
SESAR	Single European Sky ATM Research
SMR	Short/medium range
SOTA	State of the art
SUGAR	Subsonic Ultra Green Aircraft Research
T+W	Tube and wing
TRL	Technology readiness Level
UERA	Ultra-Efficient Regional Aircraft
UHBR	Ultra-high bypass ratio turbofan
VLD	Very Large Demonstrator
WP	Work package
w.r.t.	With reference to

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1. INTRODUCTION

Clean Aviation Joint Undertaking will contribute to Europe's climate neutrality by 2050 by developing and implementing new and more environmentally friendly technologies in the aeronautic sector. In Clean Aviation's Strategic Research and Innovation Agenda 2035 (Clean Aviation, 2024), future aircraft concepts with advanced technologies and the projections of environmental performance improvements are described. A hybrid electric regional aircraft concept and a short/medium range aircraft concept, both with a tube and wing configuration, have the overall target of 30% CO_2 emission reduction compared to an aircraft with 2020 state-of-the-art technology. A hydrogen powered aircraft, either with H_2 direct combustion or a fuel cell-based powertrain aircraft concept would lead to a 100% reduction of in-flight CO_2 emissions.

To give an overview of recent developments, this report focuses on advanced and disruptive aircraft concepts. It is building on the top-down approach described in CLAIM Deliverable D3.1 (Szöke-Erös, 2024), which identified the most often considered technologies and technology roadmaps from aviation roadmaps. In contrast, this work adopts a bottom-up approach, focusing on research projects, papers, parametric studies, and commercial projects that feature innovative aircraft concepts. The concepts are categorised according to previously identified categories, including aircraft architecture, fuel/energy, propulsion technology, aerodynamics, and structures. A key figure of interest is the environmental-performance improvement, specifically emissions and climate effect. An analysis has been performed to obtain a general overview of the most promising and most implemented technology features on the advanced and disruptive aircraft concepts including the environmental performance. In relation with work package 2 of the CLAIM project, the utilised climate metrics for evaluating the climate impact of the aircraft concepts are also one aspect of interest.

The second part of this deliverable in the frame of the project "Clean Aviation Support for Impact Monitoring" (CLAIM) is devoted to describe the performed activities related to the WP3.2 task as contribution to D3.2 deliverable and the "Technology Impact Monitoring" initiative. These outcomes are meant to support the performance assessment of the aircraft concepts "Short and Medium Range" (SMR) and "Hybrid-Electric Regional" (HER) under development in the framework of the Clean Aviation (CA), in terms of climate impact and the potential benefit that can be obtained by the adoptions of the relevant innovative technologies, processes and operations. This assessment encompasses the main R&I programmes as: Horizon 2020, Horizon Europe, SESAR, SESAR JU and SESAR2020 ERC. The intention is to assure a global view of the different initiatives devoted to increase the awareness about the development trend toward the greenhouse gas emission mitigation goals or the possible residual gaps. Moreover, the possible synergies with the technology development from other sectors have to be taken into account, as well as the potential adoption of scalable devices and/or sub-systems developed for other aeronautical platforms and possible synergies with other industrial sectors. For such purpose, a description of the available public literature and analysis of existing advanced aircraft concepts has been reported, also in relation to the proposed new architectures (see chapter 2). In chapter 3, a description of the advanced and purpose-built research facilities or test aircraft available on a global scale, as well as the relevant aeronautical research activities and technology areas and possible synergies with other sectors (e.g. the automotive sector) is provided.

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2. Advanced and Disruptive Aircraft Concepts and Architectures

2.1 Scope

In order to provide a concise overview of advanced and disruptive aircraft concepts and architectures, a clear scope with exclusion and inclusion criteria was defined.

Information about the aircraft concepts should be publicly available and the focus lies on research programmes and research projects from renown research centres, academia as well as from industry. The aircraft concepts, and especially the ones from industry, should be, as far as can be judged, realistic, with the intention that such an aircraft could be built in the near future.

The aircraft concepts should have an innovative, advanced or disruptive aspect in their design (e.g. for a conventional tube-and-wing aircraft architecture at least an advanced engine should be included). Furthermore, the focus lies on regional (hybrid-electric) and short/medium range aircraft, powered by e.g. kerosene, sustainable aviation fuel (SAF), liquid natural gas (LNG) or hydrogen (H_2). Long-range aircraft concepts were also considered. Commuter aircraft with 19 or less seats are normally certified under CS-23 (EASA, n.d.) and not CS-25 like 'Large Aeroplanes'. Exceptionally, as they could be also used on routes that regional aircraft serve, hybrid-electric commuter aircraft with 19 seats are considered in this study.

The aircraft concepts are included if they have an entry into service year 2010 or later, which is the reference year when the first NASA N+3 concepts were published.

A certain environmental-performance improvement (such as kerosene fuel burn reduction, CO_2 reduction, NO_X reduction, …) in relation to the climate impact of the aircraft needs to be reported to take the aircraft concepts into account in the analysis and comparison.

The scope is determined by the goal to provide input for the Clean Aviation hybrid-electric and short/medium range aircraft concepts. Therefore, the exclusion criteria are the following: All battery-electric aircraft, urban air mobility (UAM) aircraft, supersonic aircraft, vertical take-off and landing (VTOL) aircraft, retrofits and dedicated cargo aircraft concepts are out of scope. Likewise, general aviation aircraft are out of scope, with the exception of (commercial) hybrid-electric commuter aircraft with 19 passengers. Furthermore, aircraft demonstrators with the intention to show the feasibility of certain technologies are not considered in chapter 2 but only in chapter 3. Similarly, research papers and reports that evaluate only a single technology or a single technology applied to an aircraft concept, without sizing and a multidisciplinary (iterative) overall aircraft design, are not considered.

2.2 Methodology

The methodology of a structured literature review has been applied to systematically search and analyse the state-of-the-art advanced and disruptive aircraft concepts and architectures. A schematic of the approach is depicted in Figure 1.

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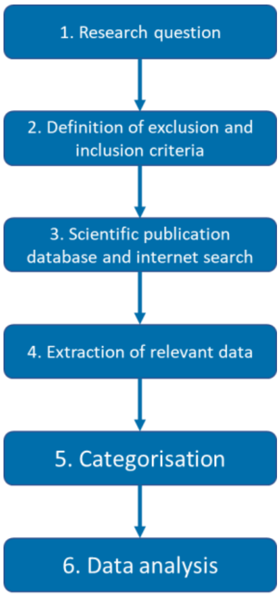

Figure 1: Methodology for literature review on advanced/disruptive aircraft concepts and architectures

The research question is: Which advanced/disruptive aircraft concepts and architectures exist and what is their environmental-performance improvement?

Exclusion and inclusion criteria were defined beforehand to facilitate the selection. These are explained in detail in section 2.1 The literature search included databases for scientific publications and the cordis-website for documentation of European research projects (European Commission, n.d.). For commercial aircraft concepts, an internet search was performed. The publications and references which met the criteria were further analysed.

The next step was the extraction of relevant data of the information on the advanced/disruptive aircraft concepts. The developer, related research project and the publication year were collected. Furthermore, the environmental-performance improvement / greenhouse gas reduction potential including CO_2 and non-CO_2 emissions, and if available an information whether these values stem from a whole flight mission were extracted. The values for a (design) mission/block fuel were retrieved, and when ranges were provided, either the averages or the indicated nominal values were selected.

The environmental-performance improvement of the new concepts is normally compared with a reference aircraft. The technology level of the reference aircraft has been categorised: traditional for an aircraft technology level earlier than 2015, state-of-the-art for aircraft with a technology level between 2015 and 2025, and future for technology levels after 2025.

Then, the categorisation of the aircraft concepts took place. First, the concepts were classified as to whether they are the result of a research project, investigated in other research papers in the form of parametric studies, or whether they are a commercial concept. Second, the concepts were classified as being either regional, short/medium range, long-haul or commuter aircraft.

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As a next step, the categorisation, aligned with Deliverable D3.1, is performed for the categories architecture, fuel/energy, propulsion, aerodynamics and structural concepts. The same options as in the technology roadmaps from D3.1 are considered. The category options of the technology roadmaps for ‘Systems Technologies’ are not considered as the conceptual/preliminary design studies often do not provide this level of detail and because the systems often do not lead to a directly quantifiable aircraft emission reduction. The category options related to ATM technologies are also not further considered, as the aircraft concepts were evaluated on a single-mission basis. When ATM improvements were explicitly mentioned, they were categorised under “other relevant technologies”.

Section 2.4 gives a more detailed explanation of the categories and the options therein.

The aircraft concepts are sorted per date and per group: NASA N+2/N+3/N+4 concepts, concepts developed in Horizon Europe/Horizon 2020/7th Framework Programme for Research, concepts developed in Clean Aviation JU/Clean Sky 2, other research programmes, other scientific papers/parametric studies and commercial aircraft concepts.

Finally, the collected data is analysed, as described in sections 2.5 and 2.6. Other climate metrics used for measuring climate impact are detailed in section 2.7, and conclusions are presented in section 2.8.

2.3 Advanced/disruptive aircraft concepts in past and ongoing research programmes

Various research and innovation programs are aiming to reduce aircraft emissions and increase efficiency in aviation. These research programs are funded by government agencies, private organisations and (inter)national institutions. In this context, two larger programmes are elaborated upon: the European Union funded projects and the NASA National Aeronautics and Space Administration funded projects.

2.3.1 NASA N+2/N+3/N+4

A series of NASA-funded concepts were developed in the Subsonic Fixed Wing Project for different timeframes: N+2, N+3 and N+4. Here, ‘N’ stands for the current generation of aircraft in operation (referring to in-service standards in 2010 but the entry-into-service date of the reference aircraft can be earlier), with N+2, N+3 and N+4 referring to the second, third, and the fourth generations, respectively. For each timeframe a set of goals regarding noise, LTO NOx emissions and take-off/landing field length are posed.

NASA / Boeing N+2

Within the N+2 programme, Environmentally Responsible Aviation (ERA) concepts were thoroughly studied by NASA. The block fuel reduction target was set at 50% reduction compared to 2005 best-in-class reference aircraft. The LTO NOx emissions reduction target

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was -75% below CAEP/6 values. The cumulative noise margin relative to Stage 4 noise levels should be decreased by 42dB and the technology readiness level (TRL) should be of 4 to 6 by 2020.

In a study published in 2011, Boeing contributed to the ERA project by looking into N+2 timeframe advanced aircraft design concepts (Bonet, et al., 2011). Three representative aircraft configurations for entry-into-service by 2025 were considered: a conventional tube-and-wing aircraft, an advanced double deck mid-engine tube-and-wing aircraft and a blended-wing-body design. Three different advanced engine technologies were the options: an advanced Rolls-Royce three spool turbofan, a Pratt & Whitney geared turbofan (GTF) and a Rolls-Royce open rotor (OR).

In 2016, NASA published the latest status and the performance assessment of the down selected ERA aircraft concepts (Nickol & Haller, 2016). The ERA concepts consist of conventional tube-and-wing (T+W) concepts of different sizes: regional jet, single aisle aircraft, small twin aisle aircraft, large twin aisle aircraft and very large twin aisle aircraft. For the regional jet and single aisle T+W aircraft, unconventional alternatives of over-wing-nacelle (OWN) aircraft are studied to compare performance. For the small twin aisle, large twin aisle and very large twin aisle aircraft, unconventional hybrid-wing-body (HWB) alternatives are sized. Lastly, one additional unconventional mid-fuselage-nacelle (MFN) concept is sized as an alternative to the conventional large twin aisle aircraft. Furthermore, two engine types were studied: a direct drive (DD) engine and a geared-turbofan engine (GTF). All aircraft make use of advanced engine technologies such as highly loaded front block compressor (HLFC), second generation ultra-high-bypass (UHB) propulsor integration and low NOx fuel flexible combustor integration.

Northrop Grumman N+2

Within the Environmentally Responsible Aviation Project, Northrop Grumman Systems Corporation studied the conceptual design for transport aircraft with EIS in 2025 (Drake, Harris, Komadina, Wang, & Bender, 2013). The work was completed together with Rolls-Royce, Wyle Laboratories and Iowa State University. The study looked into conventional tube-and-wing aircraft reference aircraft and unconventional flying wing and multi-body configuration alternatives. Although the multi-body configurations performed well, the flying wing configuration performed significantly better and is therefore the main goal of the further study.

DZYNE N+2

DZYNE technologies investigated BWB aircraft configurations for both the regional and single-aisle jet categories to achieve the N+2 strategic goals (Yang, Page, & Smetak, 2018). First a single-deck subsonic BWB with 112 passengers was investigated, named the Ascent 1000. The aircraft features semi-buried geared turbofan engines, without BLI. After this, a BWB configuration family is designed in which the Ascent 1000 is upscaled in several steps up to a 210-passenger airline. Eventually, a 165-passenger BWB is compared to best-in-class single-aisle benchmark. The aircraft uses PW1217G geared turbofan engines with projected improvements for 2025 entry into service.

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Lockheed Martin N+2

Lockheed Martin developed a long range box wing architecture aircraft which integrates advanced turbofan engines at the rear wings (Mangelsdorf, 2011). It incorporates advanced propulsion technology, new lightweight materials, laminar wing aerodynamics. No publicly available information on the environmental performance improvement was found.

Also, for the N+3 timeframe, several aircraft concepts were investigated in the NASA Subsonic Fixed Wing Project. This time, entry-into-service is foreseen at 2030-2035. The fuel burn reduction should be better than -70-% compared to 2005 best-in-class aircraft, the LTO NOx emissions should be better than -75% below CAEP/6 and the cumulative noise should be -71dB below stage 4.

Boeing N+3

Boeing, in collaboration with General Electric (GE) and Georgia Institute of Technology, has been working on the Subsonic Ultra Green Aircraft Research (SUGAR) project (Bradley & Droney, 2011; Ashcraft, Padron, Pascioni, Stout, & Huff, 2011; Wahls, Del Rosario, & Follen, 2010; Droney, Sclafani, Harrison, Grasch, & Beyar, 2020).

The aircraft concepts are based on a Boeing 737-800. The team first developed kerosene powered N+3 aircraft. A conventional tube and wing aircraft, called Refined SUGAR, incorporates future technologies such as a GE ultra-high bypass ratio engine with improvements to the core, natural laminar flow, riblets on the fuselage and it is built from composite materials. This concept, as well as all other N+3 SUGAR concepts are evaluated on missions compatible with Next Gen ATM leading to fuel burn savings and the hydrocarbon fuel is low sulphur Jet-A, synthetic fuel or biofuels. For the “Super Refined SUGAR” the wing span constraint was lifted leading to the optimum span. It utilises an even more advanced engine and higher bypass ratio than Refined SUGAR. The high span truss braced tube and wing configuration “SUGAR High” also uses the more advanced engine from Super Refined SUGAR. It has a high aspect ratio wing and further aerodynamic improvements. The last only-kerosene concept is the hybrid wing body “SUGAR Ray”.

Then, also hybrid-electric N+3 aircraft were developed (Bradley & Droney, 2015). An unconstrained wing span aircraft with a tube-and-wing configuration “SUGAR Electric Eel” uses hybrid electric gas turbine engines, partly powered by batteries for the propulsion. The hybrid wing body “SUGAR Sting Ray” also has a hybrid electric gas turbine. The high span truss braced tube and wing configuration “SUGAR Volt” combines the truss braced aircraft architecture with a hybrid electric powertrain. The batteries assist during take-off and cruise. In a second phase, one balanced version and one core shutdown version with stronger engines were developed. In the latter, the engines are operated differently: the hybrid mode is used during take-off and climb, followed by an all fuel cruise segment to reduce gross weight. The remaining cruise segment is then conducted with the core shutdown and further operated on batteries.

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MIT N+3

Massachusetts Institute of Technology, in collaboration with Aurora Flight Sciences and Pratt & Whitney designed two scenario-driven aircraft configurations (MIT, 2010; Wahls, Del Rosario, & Follen, 2010; Heidmann, 2020). One of them, referred to as the H-series, is a hybrid wing body aircraft of international size. The H3.2 (sized version of the H-series) makes use of advanced aircraft and engine design concepts such as natural laminar flow on the wing bottom, boundary layer ingestion, ultra-high-bypass ratio engines, active load alleviation, advanced materials, advanced combustor, variable area nozzle with thrust vectoring and distributed propulsion using bevel gears. For the other scenario, of domestic size, a double-bubble modified tube and wing lifting body is considered and referred to as the D-series. Two fuselage tubes are smoothly merged together side-by-side. The aircraft also leverages advanced technologies, such as boundary layer ingestion and active load alleviation. Several versions of this concept are studied: the D8.1 makes use of a composite structure and the D8.5 consists of a composite structure. For both versions, also the addition of strut-braced wings are investigated.

Aurora N+3

In a later study, Aurora Flight Sciences further investigated the D8 aircraft and introduced several other design constrains and requirements beyond those of the original MIT phase (Yutko, et al., 2017). This resulted in two sized aircraft concepts: Aurora D8-2016, a subsonic transport aircraft with entry-in-service in 2016 and a version with entry-in-service 2035.

GE/CESSNA N+3

As part of the N+3 concept studies, General Electric, Cessna and Georgia Institute of technology studied a 20 passenger regional aircraft with short range which focusses on point-to-point transportation between regional airports (Ashcraft, Padron, Pascioni, Stout, & Huff, 2011; Wahls, Del Rosario, & Follen, 2010; Aircraft Completion News, 2011). The aircraft is developed with a 'magic skin' with self-healing properties called STAR-C2 'Smoothing, Thermal, Absorbing, Reflective, Conductive, Cosmetic'. The aircraft has a self-cleaning surface with ice protection. Furthermore, the concept utilises an advanced ultra-quiet and efficient turboprop (UQETP) with composite propeller blades, spinner, gearbox, engine mount tube, inlet and nacelle.

Northrop Grumman N+3

According to the same reduction goals in NOx, noise and fuel burn, Northrop Grumman studied the Subsonic Fixed Wing Silent Efficient Low-Emissions Commercial Transport (SELECT) vehicle for the N+3 timeframe (Bruner, et al., 2010). Initially, a wide design space of aircraft configurations was considered, however the final concept features a conventional tube-and-wing. The aircraft is equipped with an innovative engine technology suite, consisting of an advanced three-shaft turbofan engine with ultra-high-bypass ratio, intercooled compressor stages, ceramic matrix composite turbine blades and lean-burn combustor, variable nozzle geometry and compressive flow control.

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NASA (internal/other) N+3

NASA studied the N3-X concept for the N+3 timeframe (Felder, 2015). However, the climate impact reduction goals have been updated with respect to the previous mentioned values. The aircraft, with entry into service by 2025 are targeted with a cumulative noise reduction margin of -52% relative to stage 4, LTO NOx emission reduction of -80% relative to CAEP/6 and aircraft fuel reduction of -60% with respect to 2005 best-in-class aircraft. This time, also cruise NOx emissions are considered and targeted at -80% with respect to 2005 best-in-class. The N3-X concept is a hybrid-wing-body aircraft configuration with turboelectric distributed propulsion. The aircraft features many small, distortion-tolerant fans for a high effective bypass ratio, superconducting motors and generators and a highly efficient gas generator. The wide propulsor array maximises the boundary layer ingestion and wake filling.

On another concept, TBW-XN, developed by NASA, NIA, Virginia Tech and Georgia Tech, only limited information was publicly available (Wahls, Del Rosario, & Follen, 2010). It is a strut-braced wing concept with a laminar flow wing and an aft-fuselage boundary layer ingestion (BLI) engine.

NASA N+4

In the NASA N+4 project, based on the strut braced wing concept, other fuels/energy and propulsion concepts were investigated which could be operational in the 2040 timeframe: liquified natural gas (LNG), hydrogen, fuel cell hybrids, battery electric hybrids, low energy nuclear (LENR), boundary layer ingestion propulsion, unducted fans and advanced propellers, and combinations (Bradley & Droney, 2012). The variations of LNG fuelled aircraft (SUGAR Freeze) need a cryogenic fuel tank. A Refined N+4 tube and wing version, a N+4 truss braced wing, and LNG truss braced wing versions with different engines (hybrid-electric engines, open rotor, boundary layer ingestion engines) were further investigated. Finally, the hybrid-electric LNG fuelled aircraft with unducted fans / open rotor engines was the most promising version in terms of fuel burn reductions.

2.3.2 Horizon Europe/Horizon 2020/7th Framework Programme for Research

The three most recent European Union funding programmes for research and innovation are the 7th Framework Programme for Research (FP7, 2007-2013, budget over 50 billion € of which €4.1 billion was the total budget for Transport including Aeronautics), Horizon 2020 (2014-2020, budget nearly 80 billion €) and Horizon Europe (2021-2027, budget €95.5 billion) (European Commission, n.d.)

These research programmes include funding for the development of more efficient, quieter and environmentally friendly aircraft. The projects that developed a new aircraft concept that falls in the scope of this literature review, are described in this section.

Under Cluster 5: Climate, Energy & Mobility, the Clean Aviation Joint Undertaking with the associated projects falls, which is treated separately in Section 2.3.3.

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AHEAD (FP7)

The AHEAD (Advanced Hybrid Engines for Aircraft Development) project includes an aircraft study of a novel hybrid engine concept for a multi-fuel Blended Wing Body aircraft (Rao & Yin, 2014; Grewe, et al., 2016). The hybrid engine concept features several novel propulsion concepts such as counter-rotating fan for boundary layer ingestion and a dual combustion chamber in which two types of fuels are considered in series in two combustion chambers. In the first combustion chamber, liquid natural gas or liquid hydrogen is combusted. A part of the emerging exhaust is inserted into the second combustion chamber, fuelled with (bio-)kerosene and burnt in an inter-turbine flameless combustion.

ULTIMATE (FP7)

The ULTIMATE (Ultra Low emission Technology Innovations for Mid-century Aircraft Turbine Engines) project developed innovative propulsion systems to reduce energy consumptions and CO2 emissions towards 2050 (Heinemann, et al., 2017). In the project, two tube and wing configuration aircraft for the year 2050 were developed. First, an intra-European (iE) aircraft with an Open Rotor in pusher configuration installed at the rear fuselage and second an intercontinental (IC) platform powered by under-wing mounted advanced Geared Turbofan (GTF) engines. The engines comprise advanced technologies such as new materials for improved temperature resistance and reduced weight. Structural advancements are taken into account as well as several aerodynamic concepts and technologies are applied such as high aspect ratio wings, foldable wing tips, a Variable Camber system enabled by trailing edge flaps, a hybrid laminar flow system etc. A fuel cell powered by liquid hydrogen is integrated for an all-electric aircraft systems architecture and to enable emission free taxiing.

DisPURSAL (FP7)

The main goal of the project DisPURSAL (Distributed Propulsion and Ultra-high By-Pass Rotor study at Aircraft Level) was to study the implementation of distributed propulsion and the resulting overall aircraft performance benefits (Bauhaus Luftfahrt, n.d.; Iskiveren, et al., 2015). The project resulted in two aircraft configurations: The first concept integrates the fuselage with a single propulsor in a Propulsive-Fuselage Concept (PFC). The concept has a conventional tube-and-wing architecture and the propulsion system uses ultra-high bypass ratio engines and an aft-fuselage boundary layer ingestion engine. The second concept employed distributed propulsion on a Distributed Multiple-Fans concept (DMFC). The aircraft architecture considered for this concept is a hybrid wing body. For both concepts, apart from conventionally fuelled concepts, also hybrid-electric variants were investigated in which a serial power-train arrangement was considered.

CENTRELINE (Horizon 2020)

The CENTRELINE (concept validation study for fuselage wake-filling propulsion integration) project focuses on the Propulsive Fuselage Concept (PFC), which aims to reduce CO_2 emissions by maximising the benefits of aft-fuselage wake-filling (Habermann, et al., 2020). The project uses a single propulsive device at the fuselage aft-end, driven turbo-electrically with power from generators connected to the under-wing installed advanced geared turbofan

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engines, to entrain and re-energise the fuselage boundary layer flow. One single aircraft concept was the outcome that was compared with a year 2035 and a year 2000 technology level reference aircraft. This research project is based on the DisPURSAL project.

PARSIFAL (Horizon 2020)

The PARSIFAL (Prandtlplane architecture for the sustainable improvement of future airplanes) project explored the concept of a box wing design for more efficient aircraft (Cipolla, et al., 2020; Binante, Abu Salem, Cipolla, & Palaia, 2020). The goal was to assess the technical feasibility and potential benefits of this design, which aims to maximise span efficiency and reduce drag and fuel consumption. The project conducted a thorough benefit assessment, evaluating the impact of introducing the box wing design on various aspects such as aerodynamics, flight mechanics, structures, and environmental effects. Several aircraft concepts with a box wing architecture, ranging from 186 to 300 passenger versions were developed.

IMOTHEP (Horizon 2020)

The IMOTHEP (Investigation and maturation of technologies for hybrid electric propulsion) project aimed to assess the potential of hybrid electric propulsion (HEP) in reducing fuel consumption and achieving carbon neutral growth in commercial aviation . The project's top-level objective was to achieve a key step in evaluating HEP's potential and build a sector-wide roadmap for its maturation. To do this, it conducted an integrated end-to-end investigation of hybrid-electric power trains for commercial aircraft, considering the propulsion system and aircraft architecture. The project focused on regional and short-to-medium range missions, selecting aircraft configurations that showed promise for fuel burn reduction. Both, conservative and radical aircraft concepts were investigated. The regional aircraft concepts with a conventional tube-and-wing architecture use kerosene and batteries as energy carriers. They either use a hybrid-electric turboprop or a distributed electric propulsion (Habermann, et al., 2023; Atanasov, Plug-In Hybrid-Electric Regional Aircraft Concept for IMOTHEP, 2022). The short/medium range concepts were blended wing bodies with either conventional turbofan propulsion or distributed (turbo)-electric propulsion, and a tube-and-wing architecture aircraft with distributed electric propulsion (Vankan, Lammen, Scheers, Dewitte, & Defoort, 2024; Nguyen Van, et al., 2024).

ENABLEH2 (Horizon 2020)

The project ENABLEH2 (Enabling cryogenic hydrogen based CO2 free air transport) aimed to develop critical technologies for liquid hydrogen (LH_2) based propulsion to achieve zero CO_2 emissions and ultra-low NO_X emissions of aviation (Rolt, Nalianda, Rompokos, & Williamson, 2018). In the project, potentials designs for year 2050 aircraft fuelled by liquid hydrogen (LH_2) for the short/medium range and long-range were designed and assessed. For both markets, a more conservative 'Lower Risk' design and a more aggressive 'Max Synergy' design were developed. The fuselage of the Lower Risk concepts is extended above the passenger cabin to accommodate the LH_2 tanks and hydrogen combustion engines propel the aircraft. The Max Synergy short/medium range tube-and-wing aircraft concept has a single hydrogen-fuelled

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turbofan engine installed at the tailfin and four battery/fuel-cell powered boundary layer ingestion fans at the trailing edge of the wing root. The wing root is thicker and larger than a classic wing as it accommodates LH_2 tanks. The geometry of the Max Synergy long-range concept is based on the blended wing body concept NASA N3-X. The Max Synergy concept has a turboelectric propulsion configuration, in which two turbofan engines located in the wing root combust hydrogen and provide electrical power to 12 remotely installed ducted fans at the upper rear surface of the blended wing body. Apart from the LH_2 version, a LNG version of this concept was developed. Moreover, for both short/medium range and long-range, tube-and-wing concepts for the year 2050 powered by either Jet A-1, biofuel or LNG serve as reference aircraft.

FUTPRINT50 (Horizon 2020)

The FUTPRINT50 (Future propulsion an integration: towards a hybrid-electric 50-seat regional aircraft) project focused on regional hybrid-electric aircraft that combine conventional engines with an electric propulsion system (dos Reis, et al., 2021; Brenner, Eisenhut, Mangold, & Moebs, 2022; Windels, et al., 2023). With an aircraft study of a 50 seat concept aircraft, key enabling technologies were identified and tools and design methods were developed. The CO_2 neutral concept uses a parallel hybrid-electric powertrain architecture in which sustainable aviation fuel (SAF) is burned in turboprop gas turbines that power electrically driven wing tip propellers. The zero emission configuration has a serial hybrid-electric architecture where primary power is provided by a hydrogen fuel cell. Electric propulsors are installed at the wing tips and distributed along the wing's leading edge.

Ongoing/about to start:

The project H_2OPE (Hydrogen optimised multi-fuel propulsion system for clean and silent aircraft) will deliver an integrated aircraft propulsion system comprising two multi-fuel ultra-high bypass ratio (UHBR) turbofan engines and a fuel cell based APPU driving an aft boundary layer ingestion (BLI) propulsor based on a tube-and-wing aircraft configuration. The project is ongoing and the aircraft concept with its environmental and emission benefits is not published yet (H2OPE project, n.d.).

2.3.3 Clean Aviation JU/Clean Sky 2

Clean Aviation is a research programme in the form of a Joint Undertaking of the European Commission (part of the Horizon Europe programme) and the European aeronautic industry. Its goal is to develop disruptive new aircraft technologies to support the European Green Deal and climate neutrality by 2050. The technologies will deliver net greenhouse gas reductions of no less than 30% compared to 2020 state-of-the-art excluding SAF effects. The programme is running from 2022 to 2030, with a total budget of €4.1 billion.

Clean Aviation's predecessor Clean Sky 2 was part of the European Union's Horizon 2020 Framework Programme and a Joint Undertaking of the European Commission and the European aeronautics industry (Clean Aviation, n.d.; European Commission, 2018). It ran from 2014 to 2021 and had a total budget of approximately €4 billion. The ambition of Clean

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Sky 2 was to reduce CO_2, NO_X and noise emissions by 20-30% compared to aircraft with an EIS 2014. Besides improving the environmental impact of aeronautical technologies, the objective of Clean Sky 2 was also to develop a strong and globally competitive aeronautical industry and supply chain in Europe.
Several projects that developed new aircraft concepts and which are part of the Clean Aviation and CleanSky2 are presented in this chapter.

One out of three Innovative Aircraft Demonstrator Platforms is the Large Passenger Aircraft Innovative Aircraft Demonstrator Platform, in the scope of which the projects PHA2-TipProp, Large Passenger Aircraft with Distributed Ducted Electric Fans, ADEC and NOVAIR developed advanced aircraft concepts. Moreover, a description of other relevant Clean Sky 2 and Clean Aviation projects that developed advanced aircraft concepts is provided.

PHA2-TipProp

DLR carried out a study to evaluate the benefit from synergies in combining advanced airframe configurations with hybrid electric propulsion, where the improvements were expected due to improved global system efficiency and not due to substitution of kerosene with batteries (Strack, Chiozzotto, Iwanizki, Plohr, & Kuhn, 2017). Several configurations were considered with both parallel-hybrid (PH) and series-hybrid (SH) configurations. The configurations feature unswept high aspect ratio wings and conventional fuselage shapes. The concepts differ from concepts propulsion units at the wing tip, tailless aircraft designs and distributed propulsion concepts. The most promising is the PHA2-TipProp configuration. The aircraft features electrically driven propulsors at the wingtips for additional power during take-off and climb and improved aerodynamic efficiency due to lower induced drag.

Large Passenger Aircraft with Distributed Ducted Electric Fans

In this project, ONERA and ISAE SUPAERO developed a large passenger hybrid aircraft in a tube and wing configuration with a distributed electric propulsion architecture (Sgueglia, et al., 2018). Turbogenerators consisting of fuel burning engines and a converter device as well as batteries provide the power for the electric motors and ducted fans installed along the inner part of the trailing edge at the upper part of the wing. This has benefits as the wing surface can be reduced (in the case that the approach speed constraint is used for the wing sizing), no high-lift devices are needed and a shorter takeoff length is possible. The aircraft can also fly parts fully electric.

ADEC

In the ADEC (Advanced Engine and Aircraft Configuration) project, DLR and ONERA developed hybrid electric propulsion aircraft (Zill, et al., 2020). As part of the DLR studies, several concepts were considered: a boosted turbofan (BTF) aircraft with parallel hybrid propulsion architecture, a series/parallel partial hybrid aircraft with aft-fuselage boundary layer ingestion and canard architecture (BLI-Canard), a series/parallel partial hybrid aircraft with aft-fuselage boundary layer ingestion and fans at the wing tip (BLI-WingFans) and a series/parallel partial hybrid aircraft with aft-fuselage boundary layer ingestion where the size of the wing tips is zero (BLI-ETF). ONERA studied a turbo-electric aircraft with distributed propulsion and ducted trailing edge fans, called DRAGON.

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NOVAIR

The potential of innovative hybrid-electric aircraft has been investigated in the NOVAIR (Novel Aircraft Configurations and Scale Flight Testing Instrumentation) project (Zill, et al., 2020). The vehicle design studies were performed by TU Delft and NLR. TU Delft developed partial turbo-electric turboprop configurations: One configuration considering wing mounted leading edge distributed propulsion, a concept with wing-tip mounted propellers and a concept with a fuselage tail cone mounted propeller including boundary layer ingestion. NLR investigated a boosted turbofan aircraft with parallel hybrid architecture.

NACOR

Within the NACOR project, a Blended Wing Body configuration for a short-medium range mission was designed and optimised (Gauvrit-Ledogar, et al., 2022). It uses two conventional turbofans installed at the rear of the central body. For the engines, future performance improvements for the year 2035 are taken into account. Later, this concept served as baseline for the H2020 IMOTHEP project.

UNIFIER19

In the project UNIFIER19 (Community Friendly Miniliner) a 19-passenger near-zero-emission commuter aircraft is designed to connect smaller airports with each other and with hubs (Eržen, et al., 2021). It has a hydrogen fuel cell that drives distributed propellers along the wing and a pusher propeller at the aft-fuselage.

TRANSCEND

Within the TRANSCEND project (Technology Review of Alternative and Novel Sources of Clean Energy with Next-generation Drivetrains), NLR investigated the potential of aircraft propulsion based on hydrogen (H2), both at aircraft and fleet level (Lammen, Peerlings, van der Sman, & Kos, 2022). Three different aircraft were conceptually sized and assessed. The first aircraft is a regional turboprop powered by a hydrogen fuel cell, the second one is a short/medium range single aisle turbofan configuration which uses a parallel hybrid propulsion configuration with hydrogen combustion and hydrogen fuel cells. The last aircraft is a twin aisle turbofan configuration with propulsion based on hydrogen combustion. All aircraft are compared to their representative current kerosene aircraft and a representative future kerosene aircraft.

GLOWOPT

Within the GLOWOPT (Global-Warming-Optimized Aircraft Design) project developed climate cost functions in terms of minimising global warming and their application to the design optimisation of next generation aircraft (Proesmans & Vos, 2022). A long-range aircraft optimised for the climate metric Average Temperature Response over 100 years (ATR100) uses lower cruise altitudes to reduce contrail formation on average. Furthermore, configurations with a truss-braced wing, a turboprop and a version with a reduced design range are developed and their climate impact in terms of ATR100 is assessed. Furthermore, a more climate-friendly short/medium range aircraft is designed, also flying at lower cruise altitudes with a lower cruise speed than typical present-day short/medium range aircraft (Proesmans & Vos, 2022).

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UP Wing
The Ultra Performance Wing project focuses on key technologies for ultra-efficient short/medium range aircraft and especially on ultra-performance wing concepts. So far, just low-fidelity models have applied to a strut-braced dry wing configuration powered by LH_2 (Méheut, et al., 2024). The cryogenic LH_2 tanks are located in the rear of the fuselage so that there is no fuel in the wing anymore. Two concepts with a cantilever architecture (conventional tube and wing configuration) and a struct-braced wing architecture are developed, having both high aspect ratio wings and making use of load alleviation technology and new materials.

Ongoing
The ongoing Clean Aviation projects SMR ACAP (Short-medium range Aircraft architecture and technology integration Project) and HERA (Hybrid-Electric Regional Aircraft Architecture and technology integration) are two transversal projects but for which no publicly available information on the aircraft concepts is available yet.
In the SMR ACAP project focuses on the short/medium range aircraft architecture and technology to achieve the Clean Aviation goals of 30% emission reduction for 2035 compared to 2020 state-of-the-art technology.
The HERA project will develop an environmentally friendly regional aircraft with a hybrid-electric propulsion based on batteries or fuel cells as energy sources supported by SAF or hydrogen burning for the thermal source. The goals is to reach 90% lower emissions.

2.3.4 Other research projects

With the Flying V, TU Delft developed a long-haul concept where the passenger cabin, cargo hold and fuel tanks are located in the wings, creating a V-shaped body (TU Delft, n.d.).

DLR developed several aircraft concepts: a forward swept wing concept with natural laminar flow in the TuLam project (Seitz, Hübner, & Risse, 2020), a hybrid-electric 19 seater commuter aircraft in the CoCoRe project (DLR, 2020), a regional hybrid-electric aircraft with distributed propulsion in the SynergIE project (DLR, 2022), a forward swept laminar flow wing long-haul aircraft with UHBR engines as well as kerosene/SAF/hydrogen combustion powered long-haul aircrafts in the KuuL project (DLR, 2023; Wöhler, et al., 2024) and a short-medium range aircraft with improved engine performance and a higher aspect ratio in the LuFO VI-2 VirEnfREI project (Wöhler, Häßy, & Kriewall, 2024). Moreover, a mild-hybrid electric propulsion (MHEP) hydrogen aircraft, a plug-in concept with kerosene and batteries, a turboprop powered aircraft (kerosene and SAF) with foldable wingtips and a turbofan aircraft were developed for the short/medium range with tube and wing configurations in the EXACT project (Atanasov, 2022; DLR, n.d.; Wehrsporn, et al., 2022). The EXACT2 project, which just started, will look at the short-range to long-range market for SAF, liquid hydrogen or hybrid-electric powered aircraft.

Aircraft concepts developed by ONERA are: ALBATROS concept (Carrier, et al., 2012), a strut-braced wing aircraft with a high aspect ratio wing and two rear-mounted turbofans, a double bubble concept with lifting fuselage in the NOVA project (Wiart, Atinault, Hue, & Grenon, 2015) with four configurations for exploring UHBR engine integration, e.g. with boundary layer ingestion, the CICAV project (Tremolet, Gauvrit-Ledogar, Brevault, Defoort, & Morel, 2019) developed a long-haul blended wing body with conventional turbofans podded

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under the external wing, and the Gullhyver study is a hydrogen-powered strut-braced wing concept with a double bubble fuselage and open rotor engines (Aviation week, 2023).

In the Fly Zero project, Aerospace Technology Institute (ATI) developed a hydrogen fuel-cell regional aircraft, a canard (three-lifting surface) configuration short/medium range concept with hydrogen combustion, dry wing, laminar flow and folding wing-tips, and a midsize widebody concept with hydrogen combustion (Debney, et al., 2022).

JAXA (Japan Aerospace Exploration Agency) works on the Wake Adaptive Thruster concept using boundary layer ingestion engines located at the aft-fuselage, Technology Reference Aircraft 2022 with technical goals of 30% CO_2 reduction, a hydrogen e-Hybrid tube and wing concept and a hydrogen blended wing body with a gas turbine generator, hydrogen fuel cell and electric fans (Ohnuki, 2012; JAXA, n.d.).

In the NASA Advanced Air Transport Technology (AATT) project, The STARC-ABL short/medium range concept was developed that features a turbo-electric powered boundary layer ingestion engine at the aft-fuselage (Welstead & Felder, 2016; Felder J. , et al., 2022). The PEGASUS (with the further developed versions 1.0 and 2.0) is a regional aircraft concept with a parallel electric-gas architecture (kerosene and batteries), wing tip propulsors and folding inboard propellers (Antcliff & Capristan, 2017; Blaesser, Frederick, Ordaz, Valdez, & Jones, 2024). The 1.0 version also had an aft-fuselage mounted boundary layer ingestion pusher propeller (Capristan & Blaesser, 2019).

In ASCENT – FAA Center of Excellence for alternative jet fuels & environment, research on advanced aircraft concepts is carried out. Furthermore, the NASA AACES 2050 program just started, where new aircraft concepts and architectures will be developed by five different teams consisting of United States aerospace industry and universities (NASA, 2024).

2.3.5 Other papers and research studies

Outside of the previously mentioned research programs, various advanced aircraft concept studies are presented in research papers. Just studies which developed a full aircraft concept and which compare the environmental performance with a reference aircraft are added in this study's overview. Often, research papers focus on the aircraft design tools and methods, include optimisation studies that explore multiple objectives and their impact on a certain metric of the aircraft design, or technology assessments evaluating the feasibility of various concepts. The included concepts were found during the search for research projects that develop new aircraft concepts and are non-exhaustive: Safran, MTU Aero Engines, Bauhaus Luftfahrt developed a regional fuel-battery hybrid aircraft concept (Pornet, Kaiser, Iskiveren, & Hornung, 2014), TU Delft developed regional parallel-hybrid regional aircraft concepts and a hybrid-electric regional turboprop aircraft (Veldhuis & Voskuijl, 2016; Voskuijl, van Bogaert, & Gangoli Rao, 2017), Bauhaus Luftfahrt developed a hybrid electric concept with two geared turbofan engines and two outboard installed electric fans (Pornet & Iskiveren, 2015), and Safran and Bauhaus Luftfahrt developed an aircraft concept with two underwing podded gas turbines and one aft-fuselage mounted electrical motor (Iskiveren, Pornet, Vratnz, & Schmidt, 2017).

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2.3.6 Commercial

In addition to research projects, commercial initiatives also play a crucial role in reducing emissions and increasing efficiency in aviation. These initiatives are driven by both larger established Original Equipment Manufacturers (OEMs) and their suppliers (Airbus, Boeing, Embraer, Bombardier, ATR, Lockheed Martin, Northrop Grumman, General Electric, Pratt & Whitney, Rolls-Royce, SAFRAN, GKN Aerospace, Leonardo), as well as smaller companies, start-ups, subsidiaries and spin-offs (Pipistrel, Aurora, DZYNE, MagniX, Desaer, Heart Aerospace, EAG, ZeroAvia, Aura Aero, Ampaire, Universal Hydrogen, Maeve Aerospace, ESAero, Faradair, Dante Aeronautical, ...). The concepts are considered in the assessment, however the available information on the environmental-performance figures is generally quite limited.

The ZEROe concepts from Airbus are hydrogen powered, but little specific information on the environmental performance could be found. Two other Airbus concepts investigate hybrid-electric powertrains and distributed propulsion. Embraer's Energia concepts are either regional or commuter aircraft being powered by kerosene, SAF, batteries, hydrogen fuel cells or by hydrogen combustion. ATR's concept applies a hybrid-electric turbofan. MagniX and Desaer work on a hybrid aircraft with two conventional turboprops assisted by two battery powered outboard installed electric motors and propellers and the regional Heart Aerospace concept has two inboard electric motors and propellers and two outboard installed turbofans. Pipistrel develops a commuter aircraft probably powered by a hydrogen fuel cell. EAG works on hybrid-electric concepts combining batteries with either kerosene or a hydrogen fuel cell. The GKN Fokker concept has turbofans, able to operate on liquid hydrogen, SAF and kerosene. ZeroAvia's regional aircraft uses hydrogen fuel cells, Aura Aero's and Ampaire's concepts are hybrid-electric regional, Universal Hydrogen (bankrupt) a hydrogen fuel cell, the Maeve Aerospace concept has battery and kerosene/SAF powered open rotors, ESAero a turbo-electric distributed propulsion, Faradair Aerospace a triple box wing and ducted pusher propfans and Dante Aeronautical a canard concept with distributed electric propulsion.

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2.4 Categorisation of the aircraft concepts

To identify groups of aircraft concepts and document the modelled technologies on the aircraft concepts, a classification of the study context, aircraft class, aircraft architecture, fuel/energy, propulsion concepts, aerodynamic concepts and structural concepts is made. The options are shown in Table 1 and the categories are further explained in Appendix A.

Table 1: Categorisation options

Category	Possible options
Study context	Research project, other paper/parametric study, commercial concept
Aircraft class	Commuter, regional, short/medium range, long-range aircraft
Aircraft architecture	Conventional, canard, blended wing body / hybrid wing, strut-/truss-braced wing, box wing, Flying V/flying wing, double bubble
Fuel/energy	Kerosene, electric batteries, hydrogen fuel cell, hydrogen combustion, liquid natural gas (LNG), sustainable aviation fuel (SAF)
Propulsion concepts	Conventional turbofans, conventional turboprops, innovative turbofans, innovative turboprops, ultra-high bypass ratio engines (UHBR), open rotor / unducted fan engine / propfan, boundary layer ingestion engine (BLI), embedded engines, hybrid-electric turbofan, hybrid electric turboprop, distributed electric propulsion
Aerodynamic concepts	Laminar flow wing, riblets, (hybrid) laminar flow control, high aspect ratio wing, folding/morphing wing-tips, advanced wing tip devices, multi-winglet system, aeroelastic tailoring, adaptive compliant trailing edge (ACTE), variable camber wing, flaplets, hingeless/morphing flap
Structural concepts	Composites, dry wing, low weight landing gear system, multifunctional cryogenic / high temperature materials, morphing materials, anticontamination surface coating, light weight aerogel structures, transparent panels, windowless design

2.5 Analysis of predicted environmental performance

The data acquisition procedure resulted in a large Excel sheet which lists the aircraft concepts and provide information about the above mentioned categories, future aircraft technologies and emission reduction potentials. This resulted in 163 unique concepts that were considered in scope for the analysis. An overview of the concepts with information on the developing organisation, study context, related research project and the year, is given in Appendix B. For some of the concepts, little or almost no information could be found other than a concept name. Therefore, in a first attempt to filter out incomplete information, all concepts for which no

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concept name, no aircraft class, no aircraft architecture, no fuel/energy type or no study context is known, are deleted from the list. Only the concepts which have information for all of these entries are included. This filtering results in a total of 161 unique aircraft concepts. This means that from the list considered, only 2 concepts were immediately not included for further analysis due to lack of general information.

For the other concepts in the list, an overall overview can be given of the available data. To effectively visualise the distribution of data for each concept, pie charts are utilised, leveraging their ability to clearly illustrate the unique composition of each concept's entries.

First, a categorization was made regarding the study context of the project in which the aircraft concept was investigated shown in Figure 2. For the list we identified three options, as is previously described in section 2.4. Overall, most of the data (78%) originates from research projects, due to the elaborate studies and thorough documentation on these kind of projects. Secondly, quite some concepts are coming from commercial parties, however it was observed that the amount of data for these concepts is often very limited. Lastly, only a few other parametric/paper studies were included.

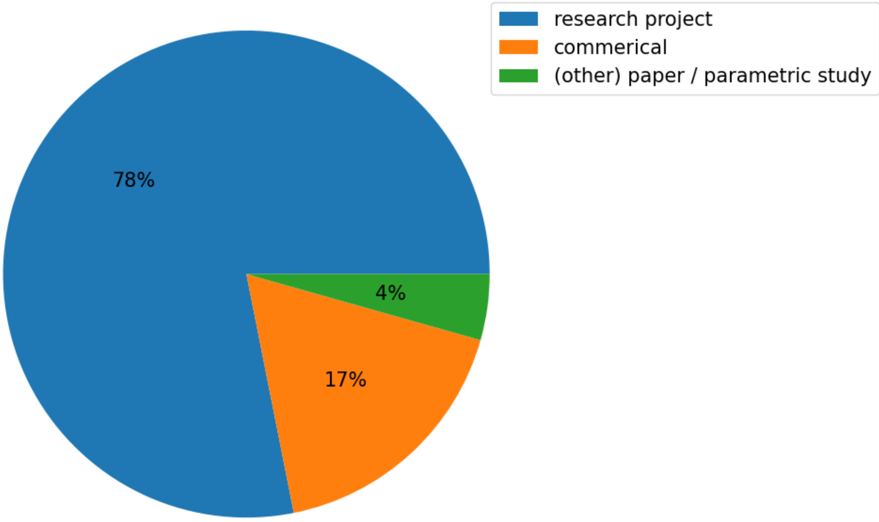

Figure 2: Distribution of study context

The aircraft concepts have been categorised into four groups based on design class, as outlined in section 2.4 which is visualised in Figure 3. The focus of this acquisition was on short/medium range and (hybrid-electric) regional aircraft. Therefore, the majority of the concepts fall into the short- to medium-range category. The regional and long-range aircraft are equally represented, together comprising a substantial portion of the concepts. Only a limited number of commuter aircraft are present in the list, which are included as they lie closely to the lower bound of the regional aircraft category.

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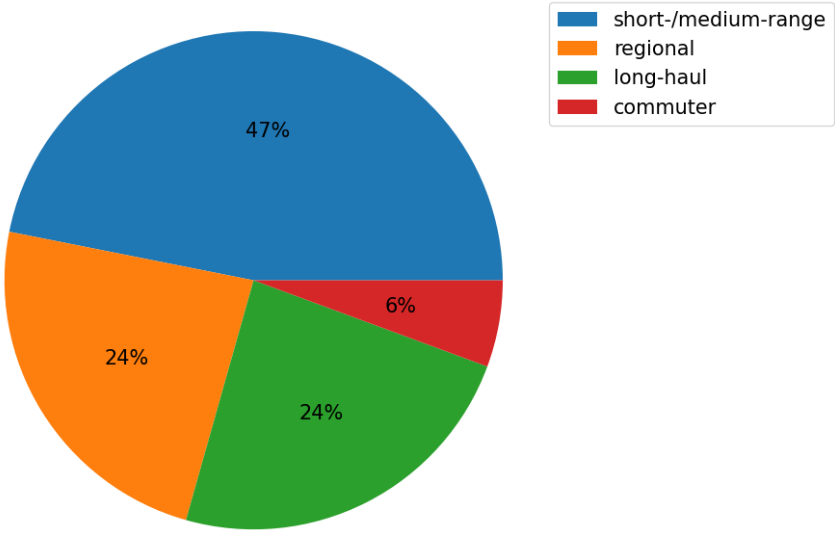

Figure 3: Distribution of aircraft class

Each aircraft concept is characterised by an aircraft architecture. Different architecture types were identified as seen in section 2.4. By visualising the data in a pie-chart in Figure 4, one can see that most aircraft concepts feature a conventional tube-and-wing architecture, after which a lot of blended-wing-body or hybrid-wing body concepts were considered. Furthermore, also strut-braced wings and double-bubble fuselages have been adopted by quite some concepts.

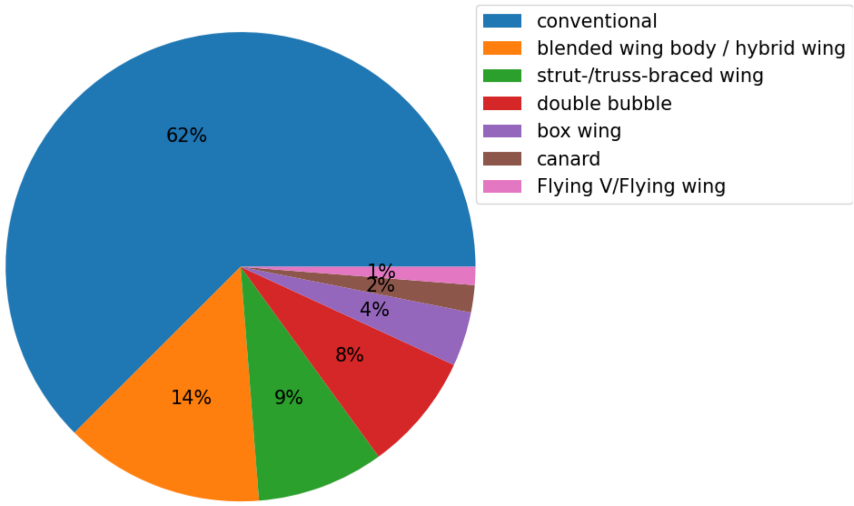

Figure 4: Distribution of aircraft architectures

The next step involved examining the kerosene fuel burn, CO_2 and NO_X reduction potentials for each aircraft configuration. These reductions are visualised in bar charts, with each chart displaying the reduction potential relative to a reference aircraft. An overview of the

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investigated aircraft concepts providing the link of the concept name with the developing organisation, study context, related research project and the year, is given in Appendix B. To ensure fair comparisons, the reference aircraft were categorised into three technology levels based on their EIS/technology level, as described in section 2.2. Separate bar charts were created for each baseline technology level and for each metric (kerosene fuel burn, CO_2, and NO_X). In each chart, the x-axis lists the aircraft concepts, while the bar length represents the percentage reduction in the considered metric relative to the reference aircraft. The reference aircraft is indicated above each chart. Additionally, similar to the pie-chart categorization, the aircraft concepts are color-coded according to their architecture and grouped by aircraft size, from smaller to larger aircraft (commercial, regional, small-medium-range, and long range), allowing for a structured comparison of reduction potentials. It might be the case, that one aircraft concept is compared to multiple reference aircraft, with similar or different baseline technology levels.

Kerosene fuel burn reduction

The first set of plots, Figure 5, Figure 6 and Figure 7, consider the reduction potentials of kerosene fuel burn with respect to reference aircraft of different technology levels. Most concepts list the kerosene fuel burn reduction compared to a reference aircraft with the same amount of passengers on the same mission. However, for some concepts a different reference aircraft or mission is used to provide the kerosene fuel burn reduction. In this case the relative improvement in kerosene fuel burn per passenger-kilometre (kerosene fuel burn/ (PAX*km)) is listed.

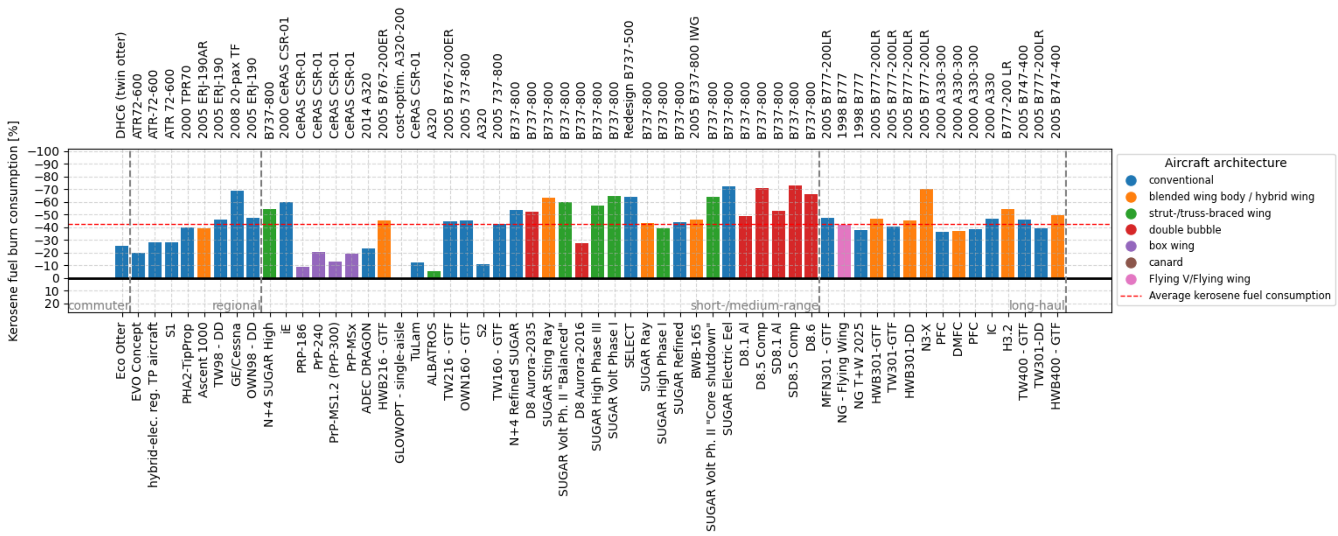

Figure 5: Kerosene fuel burn consumption compared to traditional reference aircraft

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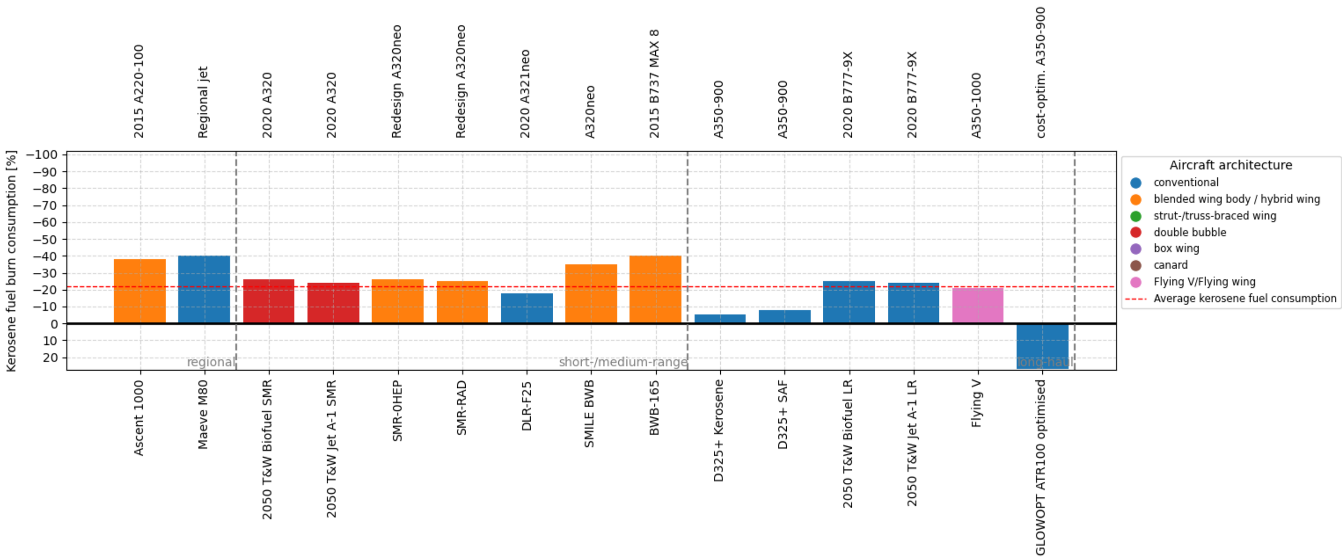

Figure 6: Kerosene fuel burn consumption compared to state-of-the-art reference aircraft

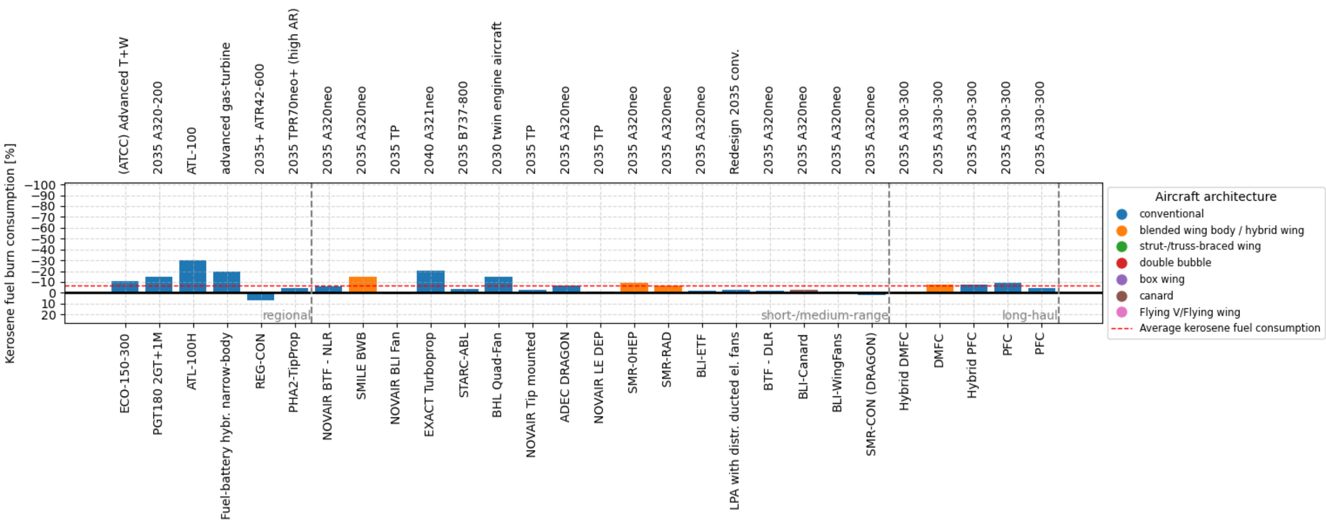

Figure 7: Kerosene fuel burn consumption compared to future reference aircraft

From the above graphs, already a few conclusions can be gathered. In Figure 5, a lot of aircraft architectures are represented by the coloured diagrams, meaning a lot of aircraft with different architectures have been compared to reference aircraft with traditional technology levels. One can observe that the blended-wing-body aircraft architectures are mostly present in the long-range aircraft, while the commuter and regional aircraft are often considering conventional architectures. For the short-medium-range, a lot of different aircraft architectures were investigated, such as box-wing aircraft, double-bubble aircraft and strut-braced wings.

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The relationship between kerosene fuel burn potential and aircraft architecture is complex, making it challenging to attribute kerosene fuel burn reductions to a single architecture. This is because multiple factors, including the energy carrier, aerodynamic, propulsion, and structural advanced technology concepts, also significantly influence kerosene fuel burn potential, alongside the aircraft architecture itself.

However, what can be concluded from the red dotted lines in the graphs, and aligns with the expectations, is that the largest (average) kerosene fuel burn reduction is achieved relative to the reference aircraft with traditional technology levels. In contrast, smaller kerosene fuel burn reductions are observed when compared to state-of-the art aircraft, and even less for future EIS reference aircraft. This indicates that advancements in technology level already incorporate significant efficiency gains.

For the aircraft concepts GLOWOPT ATR100 optimised and REG-CON the kerosene fuel burn even slightly increases compared to state-of-the-art or future reference aircraft, respectively.

CO_2 reduction

A similar exercise to the kerosene fuel burn reduction was performed to plot the CO_2 reductions of the advanced and disruptive aircraft concepts. For aircraft concepts that only use kerosene or SAF as fuel, the reduction of kerosene fuel burn equals the reduction of CO_2 as the absolute values only differ by the emission index as a linear scaling factor.

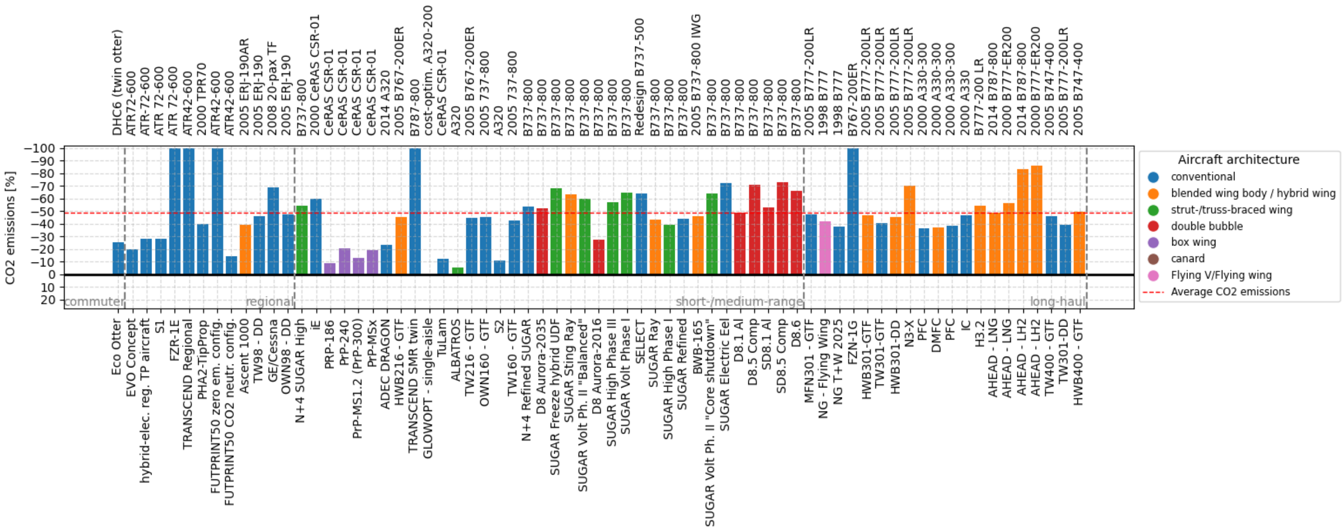

Figure 8: CO_2 emissions compared to traditional reference aircraft

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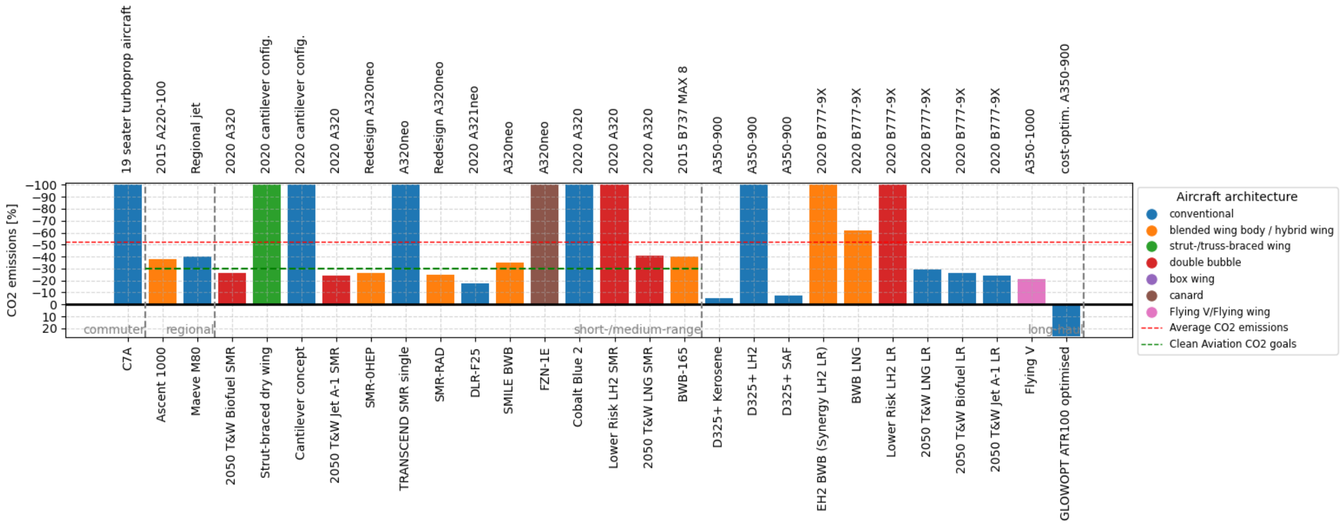

Figure 9: CO_2 emissions compared to state-of-the-art reference aircraft

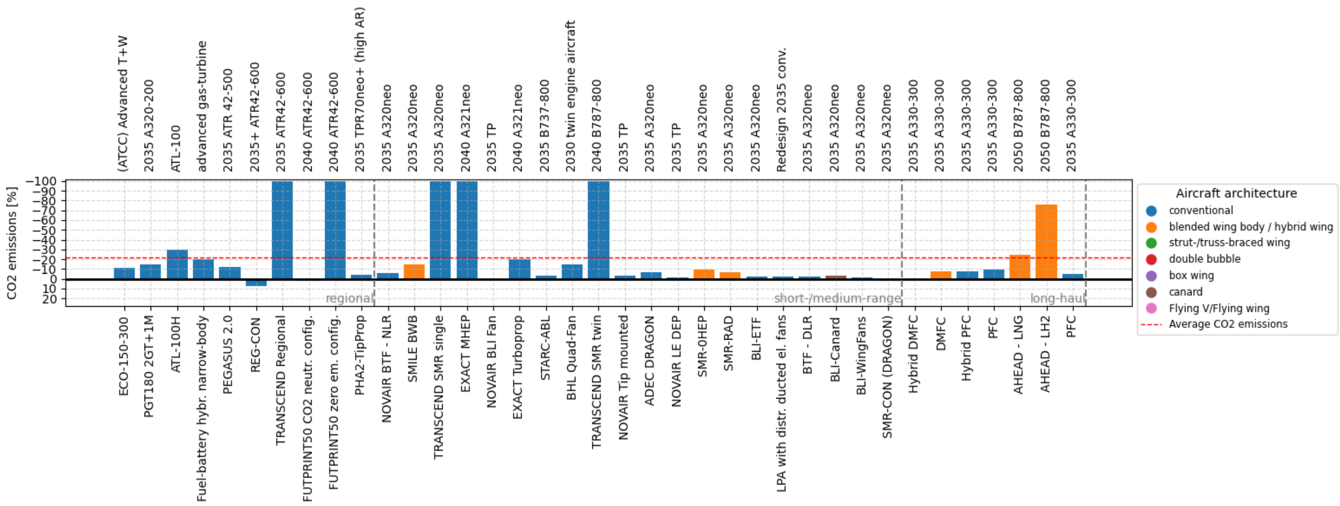

Figure 10: CO_2 emissions compared to future reference aircraft

From the plots, several observations can be made. Most of the aircraft concepts describe their emission reduction potentials in terms of a kerosene fuel burn reduction rather than a CO_2 reduction. Only a limited amount of concepts specifically mention the CO_2 reduction. However, for aircraft which use kerosene, or kerosene in combination with batteries as energy carrier, the reduction in kerosene fuel burn has a 1-on-1 relation with the reduction of CO_2. Therefore these aircraft are included in the graph and show the same reduction as in the kerosene fuel burn reduction graphs. Furthermore, for aircraft which use solely hydrogen combustion or hydrogen fuel cells as energy carriers, a 100% reduction in CO_2 emissions is achieved and thus also those aircraft concepts have been included. This eventually does result in the analysis missing a lot of information about hybrid configurations using kerosene in combination

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with hydrogen and/or liquid natural gas. This also becomes visible in the final plot with the CO_2 reduction with respect to aircraft with future technology levels. Either, the CO_2 reduction is 100%, which is related to fully hydrogen powered aircraft, or the CO_2 reduction is low (or there even is an increase in CO_2), as the improvement potential with respect to future aircraft is limited.

NO_X reduction

As before, bar charts in Figure 11, Figure 12 and Figure 13 have been created to illustrate the NO_X reduction potential of the aircraft concepts. It needs to be noted that for simplicity, no distinction is made whether the NO_X reduction is given for the landing and take-off phase (LTO) or for the whole mission.

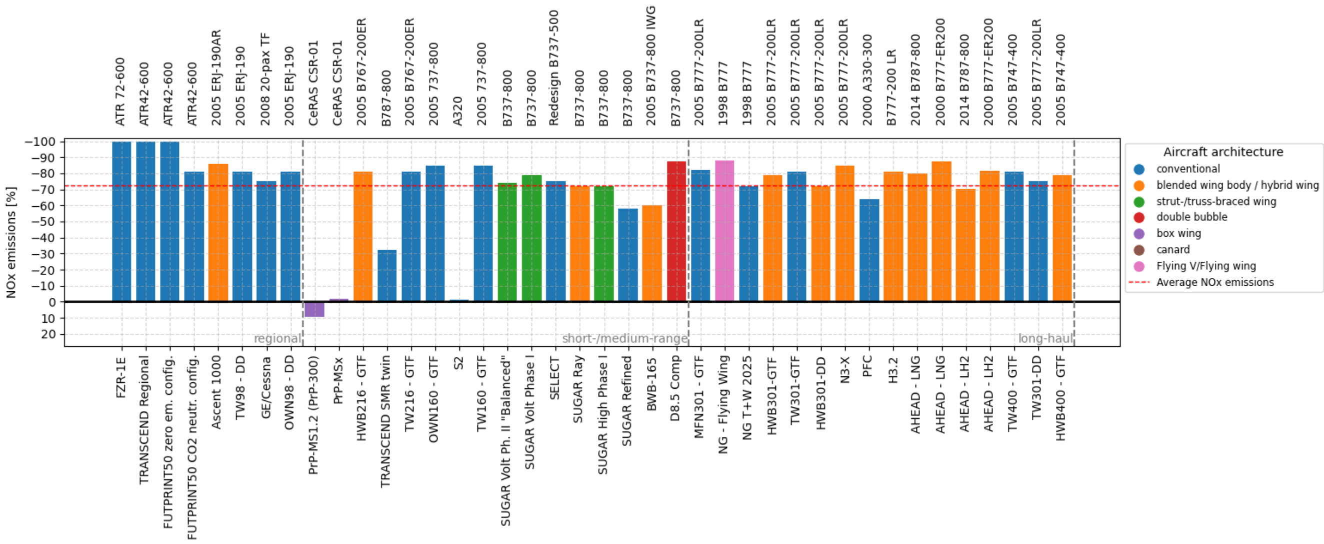

Figure 11: NO_X emissions compared to traditional reference aircraft

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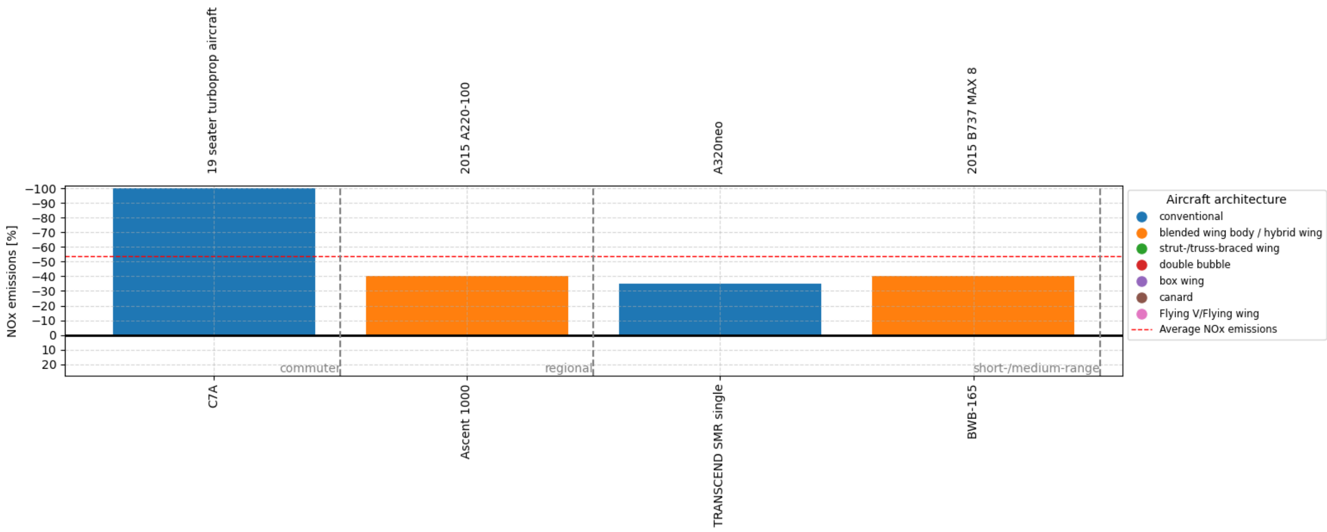

Figure 12: NO_X emissions compared to state-of-the-art reference aircraft

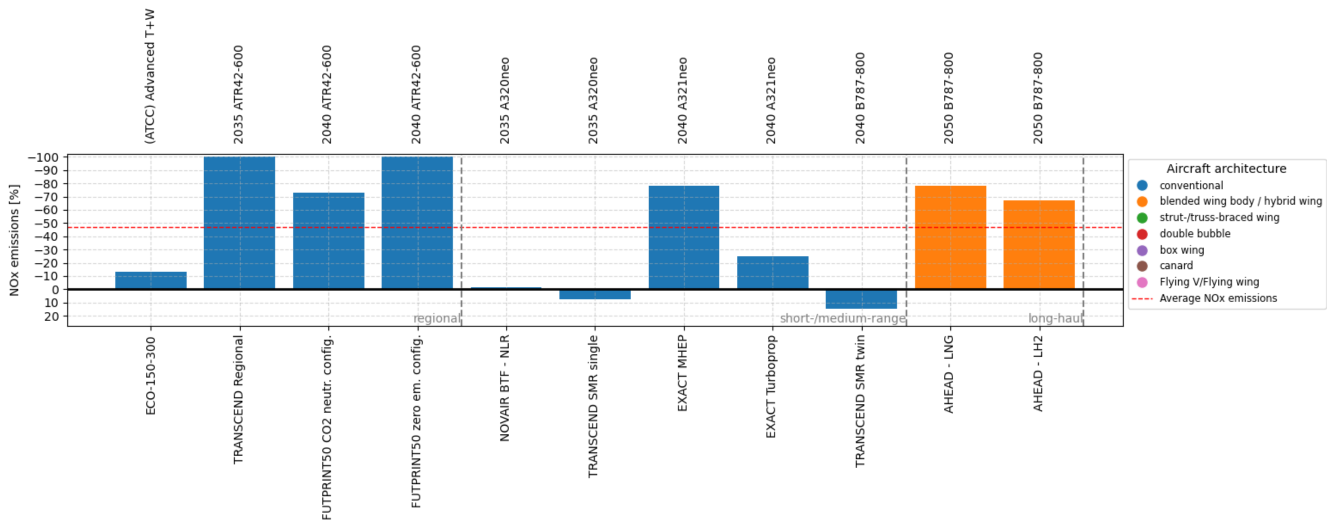

Figure 13: NO_X emissions compared to future reference aircraft

When examining the graphs related to NO_x reduction potentials, several key insights can be drawn. There are several concepts that highlight the potential NO_X reductions, as NO_X emissions significantly impact both environmental impact such as local air quality, and the climate impact of aviation. In particular, reducing the NO_X emissions during landing and take-off (LTO) was a key goal in the NASA N+2 and NASA N+3 studies. Therefore, a lot of aircraft concepts investigated in these studies are shown in the figure comparing the NO_X reductions to traditional reference aircraft. The reduction targets for LTO NO_X were high and such we observe a potential NO_X reduction between 70-80% for these concepts when compared to traditional reference aircraft.

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Furthermore, also for NO_X emissions (similar to CO_2 emissions), aircraft which make use of solely a hydrogen fuel cell are considered to have a 100% reduction in NO_X emissions. It should be noted that mostly the LTO NO_X reductions were given, while sometimes also the cruise NOx emission value was given.

In contrary to the NASA concepts, a few concepts foresee only a small reduction or even an increase in NOx production. Three concepts stand out as they list an increase in NO_X emissions: the PrP-MS1.2 (PrP-300) concept and the TRANSCEND SMR single aisle and twin aisle concepts. While the PrP-MS1.2 concept did show a decrease in CO_2 emissions, it indicates a potential trade-off between CO_2 and NO_X emissions for kerosene aircraft. The TRANSCEND SMR single and twin aisle showed a 100% reduction in CO_2 emissions due to hydrogen combustion, showing that combusting hydrogen might fully eliminate CO_2 emissions, but increase NO_X emissions, when compared to a future reference aircraft.

2.6 Environmental performance analysis with respect to utilised technologies

As mentioned before, it is hard to attribute a reduction in emissions to a single aircraft architecture, as also other factors such as energy carrier, aerodynamic design, propulsion technology and structural advancements have a significant influence on the emissions. In order to get an idea on how aircraft concepts adopt several future technologies, heat maps are created linking the aircraft concepts, their adopted technologies as categorised in section 2.4 and their environmental performance.

Some concepts only apply one or a few new technologies to study the effect on the environmental performance. Meanwhile, other aircraft concepts have the intention to include a large number of technologies that are realistic for a future EIS and integrate them in one concept to explore the possibilities of environmental impact reduction or other aircraft design related metrics such as weight reduction.

The heat maps, see Figure 14 and Appendix C, have the aircraft concepts listed on the y-axis. On the x-axis the different technology features are listed: the energy carriers, the aerodynamic concepts, the propulsion technologies and the structural technologies. The cells are coloured with a scale for their environmental improvement metric (kerosene fuel burn reduction, CO_2 reduction or NO_X reduction). The scale ranges from blue/green for large environmental improvements to orange for small improvements and to red for increase in environmental impact. Again, in order to enable fair comparison of the reduction potentials, the data is split per metric and per reference aircraft technology level (traditional, state-of-the-art, future).

With this heat map, one can obtain information about which concept is utilising which new technologies and which technologies are combined, by looking at coloured cells in the horizontal rows. It should be noted that all coloured cells in one row have the same metric colour as it is not possible to attribute a single reduction potential to a single technology feature.

The heat map also allows to identify the most promising technology concepts as this would result in a column that has clearly green or blue cells (relating to larger emission reduction potentials).

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Furthermore, not all technologies identified from the top-down approach of D3.1 are utilised on the aircraft concepts of this overview. Only the technology features that were used, and provided a value for the environmental performance metric, are shown in the heat maps. An overview of the technologies is given in Appendix A.

Kerosene fuel burn reduction

In Figure 14 an example of such a heat map is given. This heat map provides the effects of the technology features on the kerosene fuel burn consumption with respect to reference aircraft with traditional technology level. Only technology features that are utilised in the aircraft concepts which provide a kerosene fuel burn consumption difference with respect to traditional technology baselines, are depicted in the heat map. Features that were not used, were deleted from the list but might be used in other heat maps, comparing to other baseline aircraft.

The heat map in Figure 14 shows several notable trends. Firstly, an examination of the energy carriers (fuel/energy) employed by various concepts shows that kerosene remains a dominant choice. However, some concepts also explore alternative energy sources, such as combining kerosene with batteries, which yields greater potential for reducing kerosene fuel burn. In terms of propulsion technologies, boundary layer ingestion emerges as a popular choice, offering potential for reducing kerosene fuel burn. Innovative turbofans and ultra-high-bypass ratio engines are also widely adopted, providing moderate improvements in fuel efficiency. Conventional turbofans, while still used in some concepts, tend to have lower kerosene fuel burn improvements. Aerodynamic technologies also play a crucial role, with riblets, laminar flow wings and (hybrid) laminar flow control frequently applied to achieve medium to high kerosene fuel burn improvements. High wing aspect ratios are another common feature, leading to (mostly) substantially high reductions in kerosene fuel burn. Lastly, an analysis of structural concepts reveals a most future concepts make use of composite structures.

The same heat maps are also made for kerosene fuel burn reduction with respect to reference aircraft with state-of-the-art and future technologies. These heat maps are shown in Appendix C. It should be noted that it is much harder to obtain relations between the technology features and kerosene fuel burn reduction due to less available data on adopted technology features and/or related improvements, especially for concepts with state-of-the-art reference aircraft. Furthermore, one can again observe that the kerosene fuel burn reduction with regards to future reference aircraft is limited due to advancements of technologies in these reference aircraft as well.

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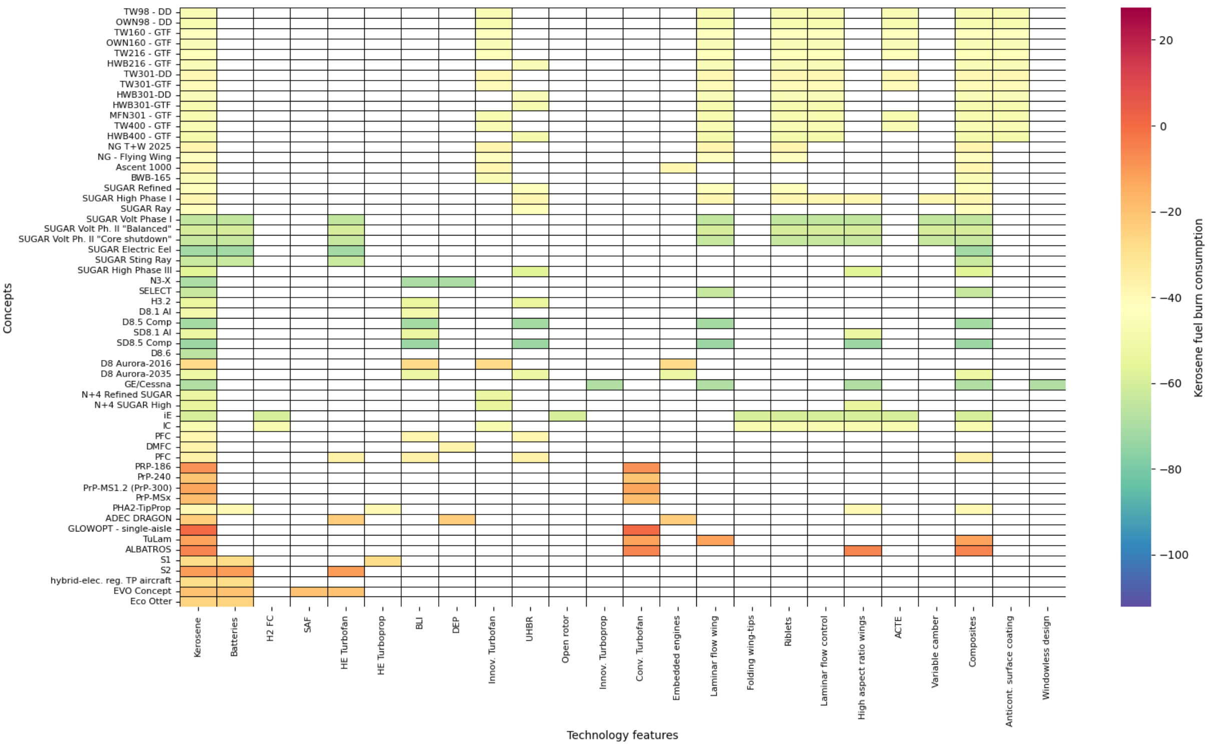

Figure 14: Heat map technology features effect on kerosene fuel burn consumption compared to traditional reference aircraft

CO_2 reduction

The heat maps presented in Appendix C also offer the visualization of each concept's CO_2 reduction potential and adopted technology features, benchmarked against reference aircraft of varying technology levels. A key observation is that the energy carrier strongly affects the CO_2 reduction potential. Concepts that utilise hydrogen combustion, hydrogen fuel cells, a combination of both or a combination with batteries, stand out for achieving 100% reduction in CO_2 emissions (showed in dark blue). It is therefore not possible to relate any CO_2 reduction to other technology features directly. It should be noted that for the concepts applying batteries, always another fuel/energy type is included as no purely battery-electric aircraft were considered and therefore the column of the batteries does not always show a 100% CO_2 reduction. For concepts that employ other types of fuel/energy, still some trends could be observed for the concepts benchmarked against traditional reference aircraft. Often BLI, innovative turbofans and UHBR engines are used on concepts that achieve significant CO_2 reductions. The impact of aerodynamic concepts such as riblets, laminar flow wings, (hybrid) laminar flow control and high aspect ratio wings on the CO_2 reduction potential can again be observed. Again, many concepts make use of composite structures, with low to high CO_2 emission reduction potential. For the concepts benchmarked against state-of-the-art and future reference aircraft, these trends are harder to see due to less data.

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NO_X reduction

The last set of heatmaps in Appendix C, show the NO_X reduction related to the utilised technologies compared to reference aircraft of different EIS. The main conclusions that could be drawn from these graphs are very similar to those of the CO_2 reduction, as also here the energy carrier is mostly affecting the NO_X reduction potential. A hydrogen fuel cell, similar to CO_2 reductions, achieves a NO_X reduction of 100%. With hydrogen combustion on the other hand, still some NO_X emissions (or even higher NO_X emissions) are produced. The most commonly used technology features for aerodynamic, structural and propulsion concepts are similar to those for CO_2 reduction. Also here, some trends could be observed in concepts benchmarked against traditional reference aircraft, the limited data available for state-of-the-art and future reference aircraft makes it challenging to identify clear trends.

2.7 Other utilised metrics for measuring climate impact

This section describes which other metrics were used to measure the environmental performance improvement, especially for the quantification of the climate impact. Most studies and concepts evaluate the fuel burn reduction and, in the case of kerosene-powered aircraft, the resulting CO_2 reduction. For tank-to-wake emissions, the reduction in kerosene fuel burn is relevant. However, fuel burn reduction might not be the best metric when analysing the performance of new aircraft concepts especially with different type of fuel/energy, such as hydrogen, LNG or batteries. In certain projects, such as ENABLEH2, which focus on designing aircraft with alternative fuels, the optimisation targets minimal energy consumption rather than minimal fuel burn, to account for other fuel/energy such as hydrogen or electricity.

In the Boeing SUGAR N+3 projects, the reduction of greenhouse gases (GHG) was quantified. For the MIT D8.1 and D8.5 aircraft concepts, the climate impact metric for evaluation of the aircraft performance is global temperature change as a result of the emissions. The assessment process of one aircraft flying one mission includes the change in concentrations, radiative forcing and temperature change. Life Cycle Emissions have been performed in these projects which include well-to-tank CO_2, well-to-tank CH_4 and combustion emissions. The climate metric, with the unit *(ΔT*years) / (kg*km)* is the globally averaged, time-integrated surface temperature change, normalised by productivity (payload*distance). A 800 year time frame is used to capture the full CO_2 impact. The benefit is mostly attributable to kerosene fuel burn savings.

The European AHEAD project assessed also the contrail-cirrus climate impact in detail, including the global contrail coverage and radiative forcing. For a comparison of the climate impact of all climate forcers, the climate metric ATR100 has been used. The European project GLOWOPT used the climate metric ATR100 for the optimisation of the aircraft. In the European project PARSIFAL the four metrics GWP20, GWP100, GTP20 and GTP100 were evaluated. The DLR projects KuuL used ATR100 and EXACT the climate metrics GWP100 and ATR100.

Concluding, different aircraft concepts' environmental performance cannot easily be compared with each other, if different metrics are used.

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2.8 Conclusions

Among the investigated advanced and disruptive aircraft concepts, research projects from aeronautical research centres and academia dominate. Geographically, most research projects are located in Europe and the United States, and some from Japan. From other countries, no recent developments of aircraft concepts including environmental performance indications with publicly available data were found. From commercial parties, also little data was publicly available and most being proprietary, probably due to the competition on the market. For example, the Airbus ZEROe concepts have little information on environmental performance available. From Boeing, the SUGAR concepts, developed for NASA and from Embraer the Energia concepts are public. Moreover, start-ups are developing new concepts.

About half of the found concepts are short/medium range aircraft, followed by regional and long-haul aircraft concepts. The most used aircraft architecture is the conventional tube and wing configuration, where improvements in aerodynamics, propulsion, structures and other are investigated. Blended wing bodies are mostly assessed for long-haul flights. For short/medium range aircraft a lot of different architectures were investigated, such as strut-/truss-braced wing and double bubble aircraft.

The relationship between kerosene fuel burn and aircraft architecture is complex, as multiple factors have an influence, such as energy carrier, aerodynamics, propulsion and structural advanced technology. Differences due to the chosen reference aircraft are pronounced. Larger kerosene fuel burn reductions are achieved compared with older entry-into-service (EIS) aircraft than state-of-the-art or future aircraft. Often, the future reference aircraft already incorporates significant efficiency gains. For kerosene powered aircraft and aircraft using kerosene in combination with batteries as energy carrier, a direct translation from fuel burn to CO_2 reductions can be assumed. A few concepts even lead to a slight increase in kerosene fuel burn and resulting CO_2 emissions coming from trade-offs with other engine emissions. NO_X emission play an important role for the environmental impact (e.g. local air quality) and climate impact. In particular, lower LTO NO_X emissions were a goal of the NASA studies. Most NO_X reductions relate to LTO NO_X but sometimes cruise NO_X were modelled. Hydrogen fuel cells lead to zero CO_2 and zero NO_X emissions. For a few concepts, the increase in NO_X could be traced back to either a trade-off with CO_2 or hydrogen combustion with high NO_X emissions.

It is hard to attribute general emission reductions to specific aircraft technology features and architectures. Some concepts apply only one or a few new technologies while other concepts have the intention to include a large number of technologies. An attempt to identify promising technologies is made using heat maps. The energy carrier strongly influences the CO_2 and NO_X reduction potential with hydrogen and batteries reducing CO_2 emissions by 100%. No purely battery-electric concepts are considered in this study as with current technology batteries have a large weight penalty. For the fuel/energy, most concepts applied kerosene, but there are also combinations with batteries or hydrogen fuel cells. A few concepts considered liquid natural gas (LNG) or sustainable aviation fuel (SAF). For the propulsion, concepts with innovative engines (also e.g. hybrid-electric fans) and the aero-propulsive concept of boundary-layer ingestion (BLI) had large improvements. Innovative turbofans such as ultra-high bypass ratio (UHBR) turbofans are promising. For regional concepts, the hybrid-electric powertrain enables distributed electric propulsion. In terms of aerodynamics, most applied technologies are high aspect ratio wings, drag reduction (e.g. riblets for skin friction drag reduction), and laminar flow control which can be well combined with high aspect ratio

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wings. From a structural point of view, most concepts make use of composites leading to weight reductions. The NASA SUGAR concepts included large improvements from operations and ATM.

The environmental performance improvement can be as high as 40-50% kerosene fuel burn and CO_2 reductions and around 70% NO_X compared with traditional (EIS before 2015) reference aircraft. For most concepts a kerosene fuel burn reduction is reported, which might not be the best metric when analysing the performance of aircraft with alternative fuels/energy. Then, mostly the metric minimal energy consumption was used. For some concepts, the climate impact was assessed. Different climate metrics, such as global temperature change over 800 years (in NASA N+3 MIT project), GWP20 (in PARSIFAL project), GWP100 (in PARSIFAL and EXACT project), GTP20 (in PARSIFAL project), GTP100 (in PARSIFAL project) and ATR100 (in AHEAD, GLOWOPT, KuuL, EXACT project) were used.

Finally, it should be noted that most of the data was derived from conceptual studies. Usually during conceptual studies, low fidelity methods are used, e.g. because many variants need to be explored and only few details are known. This leads to uncertainties in the results which can only be reduced during later design stages. In several cases, e.g. in the larger research projects, methods have been used which are expected to lead to results with higher fidelity. However, in this study no distinction was made between different fidelity levels due to the lack of appropriate metrics for comparison.

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3. Advanced and purpose-built research facilities or test aircraft and demonstrators (worldwide)

3.1 Scope

The scope of the present report is to concur to the identification and description of the advanced and/or disruptive aircraft concepts and architectures, purpose-built research infrastructures as well as the advanced aeronautical researches and technologies which have been considered, in the frame of the Clean Aviation (CA) programme, for the concepts SMR aircraft and HER. This theoretical based "Technology Watch" exercise has been extended in order to identify also other relevant initiatives providing solutions that could reinforce the environmental benefits related to the climate impact due to anthropogenic activities in the aviation sector.

The main objectives of this activity are:

- To support a preliminary performance assessment of a possible version of the CA SMR as well as for a CA HER similar aircraft;
- To specify the methodology approach;
- To support the definition of a related categorisation in terms of reference concepts, architectures and adopted technologies;
- To identify, list and describe the related advanced and purpose-built research facilities;
- To identify, list and describe the test aircraft or demonstrators which adopt interesting technologies potentially applicable to aircraft concepts in relation to possible scalability of the propulsive powertrain sub-system, a further increase of the air transport efficiency, etc…;
- To identify, list and describe the relevant aeronautical research activities, including those from other sectors that could lead to useful synergies;
- To support the technology mapping referring to aerodynamics, structural and propulsion systems and the comparison in terms of benefits with those from Clean Sky 1/2 and Clean Aviation;
- To complement the gap assessment in relation with Task 2.2.

A single common repository has been created at project level that is able to assure a representative mapping of the several studied innovations. Such description has been refined to support the evaluation of relevance levels, enabling the filtering and sorting of projects by relevance, in relation to the expected CLAIM goals.

3.2 Climate Knowledge State of the Art

Homogeneously to the described methodology approach, the first step has been devoted to identify the on-going natural phenomena affected by human activities. The climate impact contribution of air transport has become a driving aspect for any element of the Air Transport System (ATS) as well as for the whole aviation sector. The effort at this stage focuses on

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developing rapidly a concise and clear vision of the main problems currently experienced by populations, as well as the anticipated future risks for humanity. First of all, it has to be underlined that only the long-term effects are considered relevant for the climate impact assessment.

3.3 Relevant climate themes

The driving themes for task WP3.2 have been identified starting from the outcomes of the WP2 activities that will lead to D2.3. Examples are the rise of the atmospheric temperature, the increase in Green House Gases (GHG) concentration, cloud coverage, more frequent extreme weather events, the rise of the ocean water temperatures as well as the related acidification, the variation of the sea water levels, glaciers reduction and continental glacier disappearance, etc… All these aspects are monitored from space and ground stations and the phenomena are described in detail every day with a quite complete worldwide coverage. The analysis showed that in CA a special group of projects are considered as high priority projects. Consequently, these projects related to the thrust/relevant stream: HER, SMR, HPA (Hydrogen-Powered Aircraft), and some as transversal, have been considered and classified as “CA Daring Projects”. The next list shows the related projects.

CA HER: *HERFUSE, AMBER, ODE4HERA, TheMa4HERA, HE-ART, HECATE and HERWINGT;*

CA SMR: COMPANION, *FASTER-H2, Up Wing, SWITCH, HEAVEN, OFELIA and AWATAR;*

CA HPA: *CAVENDISH, HYDEA, NEWBORN, fLHYing tank, H2ELIOS, HyPoTraDe, Trophy, FAME and HEROPS;*

CA transversal projects: *CONCERTO, HERA, SMR ACAP and ECARE.*

3.4 Climate forecast needs

Typically, the collected environmental measures are used together with historical ones to support the improvement of environmental forecasts and to refine the adopted climate impact methods and the related tools. Comparison tasks are implemented too, in order to evaluate the robustness of the climate results. Agreement on the aforementioned aspects becomes weaker when considering the exposure of people to specific impacts, such as coastal territory losses, desertification, reduced freshwater availability, and forced migration. Comparison tasks are implemented too, in order to evaluate the robustness of the climate results. y developed in WP2 related to the description of the relevant climate phenomena as well as related driving parameters and considered units (e.g. referring to the International System of Units) will be shared with WP3.

3.5 Climate valuable initiatives

A survey of the European R&I projects (CA, SESAR, ERC (European Research Council) in order to identify the valuable initiatives related to “Applicative research activities”, “Mapping of

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the enablers" etc.., able to mitigate the current climate warming trend. A list of them has been created to describe their main relevant aspects referring to long term impacts. In this framework, an exploratory activity has been implemented focused on the following topics:

- Advanced aeronautical technology
- Aeronautical research activities
- Disruptive aircraft concepts and architectures
- Purpose-built research infrastructures

For each of them, the next sub-paragraphs provide a dedicated description.

3.6 Definition of methodology

A methodology has been developed and implemented to identify relevant information to support the assessment of the climate impact due to the adoption and benefits of the SMR and HER aircraft concepts. Referring to these concepts, representative baseline/reference models have been considered for comparison purpose.

The steps performed in the assessment have been:

1) To identify criteria and main aspects e.g., topic, time frame, reference concept categories, involved organisations, expected impacts, assessment level, target group and other aspects to drive the survey according to the heuristic's approach guidelines reported in D3.1 (Szöke-Erös, 2024);
2) To include in the performed survey relevant aeronautical research activities and technology areas identified for other aeronautical concept categories in order to assure a transversal view on other potential opportunities due to power train source scalability even when related to other sectors;
3) To compile a list of the advanced aeronautical research activities and technology areas, which has been explored or are under development in Europe at national and international level. That is suitable to concur with their innovations to match the EU climate goals (e.g. net-zero emission contribution at 2050) in relation to the adoption of the flight concepts, with propulsion systems based on power sources, such as: hydrogen for aviation, hybrid-electric (HE), more-electric (MorE). An index has been assigned to each project to identify in a clear and univocal way the generic record with a minimal number of elements but suitable to explain the intrinsic relevance for the topics in charge to CLAIM e.g. "*Project acronym*", "Short description" based mainly on the related title as well as other acronyms to report in a short textual form the considered aspects.
4) The main topics relevant for CLAIM are related to the concepts: "Hybrid-Electric" (HE), "Hydrogen for Aviation" (H2Av) and "More Electric" (MorE) without neglecting the "Ultra-Efficient" aircraft with their more complex architectures with the goal of a "Low Carbon Aviation". Concepts related to "New short distance mobility" as well as rotorcrafts are out of scope.
5) The main relevant aspects of the advanced or disruptive concepts are: "Concept architecture" (Arch), "Technology" (Techno), "Assessment task" (Assess), "Aircraft

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Concept" (Cnpc) as well as the involved scientific discipline. It is important to underline that a previous characterization has been developed taking into account, as a starting point, the explicit indications reported in the consulted data sources (mainly based on Cordis[1] and SESAR website).

6) It has been considered important to emphasize the existing link among the project efforts, relevant thematic aspects as well as involved scientific disciplines. For this purpose, each project that shared information on the following topics has been considered: “Aeronautical engineering”, “Air pollution engineering”, “Air traffic management” (ATM), “Sensors”, “SMR Open-Fan engine architecture”, “Aircraft”, “Airport engineering”, “Renewable energy”, “Waste treatment processes”, “Big data” “Biofuels”, “Bio mass” etc… A specific and progressive identification code has been created for each item.

7) Other aspects have been considered to assure a wider perspective of the large number of initiatives performed or on-going, as well as the scientific area involved, and/or the adopted process, the followed approach or the used validation devices. For instance: “Industrial processes” (IndPrc) for the product at ASSY (assembly) level or sub-system level, the focused area e.g. "Operation" (Opr), "Validation Task" (ValTsk), "Demonstration" (Demo), "Electric Vehicle-Test Aircraft" (EV-TA), "Transversal and coordination actions" (Transv) and "Advanced and/or Disruptive Aircraft Concept" (A&DAC).

8) Specific fields have been chosen to trace the timeline evolution of the generic project as well as the project status e.g. closed, ongoing, referring to start and ending dates including also, if expressed, the planned milestone timeframe for the innovations in terms of TRL and/or EIS. This information has been elaborated to create a reference parade of the innovative solutions of the relevant projects in support to the comparison with the reference CA roadmap and the strategic European environmental goals.

9) A note field has been used to clarify the level of advancements like: Conceptual design, Technology Readiness Levels (TRL) at starting date and at the end of the project.

10) The relevant baseline models, considered in CA for comparative purpose, are respectively the “ATR72-600” turboprop and the “A321neo” airliner for the UERA/HERA concept and SMR aircraft respectively.

11) To compile a list of the advanced or test aircraft in relation to their development/maturity status as well as the kind of demonstration adopted or performed (e.g. flight test aircraft, ground test model, test rig, power train subsystem, mock-up, etc.)

12) To compile a list of the advanced and purpose-built research facilities at worldwide level, categorize them also including a related brief description about their experimental field, the main performance characteristics or simulated conditions as well as if they are devoted to support the technological development or validate a concept by testing in relevant environmental conditions referring to capacity, performance and/or life cycle impacts, etc.

[1] https://cordis.europa.eu/

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13) To identify the more relevant phenomena and climate impact effects due to the anthropic activities considering the survey outcomes of WP2 devoted to describe the state of art related to the climate impact assessment methodologies and the preferred typical metrics and normalised variants.
14) To retrieve and identify the driving climate impact parameters adopted by the climate impact assessment methodologies, which have been considered as relevant initiatives.
15) To build-up a dedicated dataset: “CLAIM - Inventory”;
16) To assess and create a relevance map of the enablers (technologies area, architectures, demonstrators and facilities) referring to their effectiveness to mitigate the climate impact compared to the driving assessment methodology parameters identified;
17) To propose possible notes or conclusions referring to: Identified gaps, needs, existing or necessary research facilities, relevant technologies and adopted or adoptable demonstrators, etc …;

Figure 15 shows synthetically the methodology approach proposed for this task in the CLAIM project and presented during the Face-to-Face KoM, which has been hold in February 20 and 21, 2024 in Hamburg (Germany).

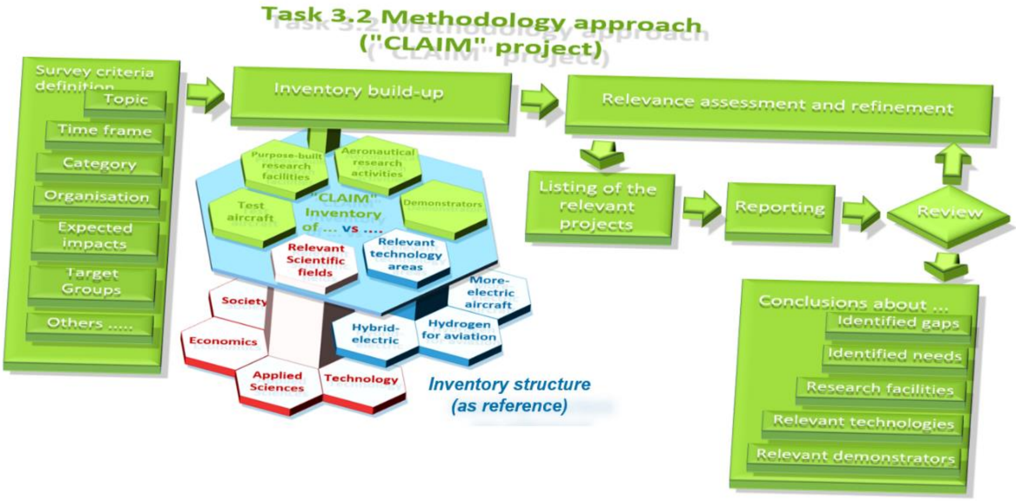

Figure 15: Proposed methodology approach (CLAIM project)

3.7 Advanced aeronautical research areas

The performed survey, of the more relevant initiatives related to the funded projects focused on the climate neutrality and air quality, has shown how the large number of innovative solutions may be traced back to specific main groups like scientific areas, disciplinary themes, industrial sector and innovative R&T thrusts/relevant streams. Based on the applied filtering,

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the following list provides a representative selection of relevant themes and/or specific categories, presented as examples:

- Environmental neutrality, emission and air quality
- Engineering activities
- Innovative materials and devices
- Involved scientific areas or disciplines
- New energy power source with low emission
- New air transport platforms or concepts
- Transversal and synergetic sectors
- Advanced aeronautical technology
- Management activities
- New operational solutions
- Circularity in aviation
- Innovative architectures

The central topic of the CLAIM project is to develop a robust assessment methodology suitable to estimate the climate change and to weight which could be the more relevant initiatives in order to match the climate neutrality by 2050. In this path, the project with an explicit reference to the *environmental neutrality, emissions and air quality* has been considered a priority. In this context the more relevant engineering activities typically adopted have been identified as: Aeronautical engineering, air pollution engineering, airport engineering, material engineering, power engineering, heat engineering and others. Details are available in Appendices D-G. Meanwhile, the *Innovative materials* and *new created devices* are related to*:* Alkali metals, alkaline earth metals, transition metals, aliphatic and inorganic compounds, composites, coating and films, textiles, fibers and carbon fibers, graphene, nano-materials.

3.7.1 Applicative research activities

The number of scientific area or disciplines applied in the development of the innovative solutions cover all sectors of the human knowledge. Moreover, to clarify the complex and highly articulated scenario involved the next lists report by cluster some of them:

Climate and Environmental Sciences

Climatology, thermo- and electro-chemistry, atmospheric sciences, environmental sciences.

Engineering and Manufacturing

Productivity, waste management, mining and mineral processing, governance, quality validation of aircraft, compliance methodologies, manufacturing engineering.

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Scientific disciplines

statistics and probability, economics, production economics, transport, mathematics, numerical programming, data science, electromagnetism and electronics, polymer science, cost efficiency, enhanced safety.

Propulsion and power sources

Energy and fuels, combined heat and power, thermodynamic engineering, Electric energy, renewable energy, liquid fuels, biofuels, hydrogen energy, electrolysis based, hydrocarbons, alcohols, fuel cell, organometallic chemistry, high voltage battery system, electric propulsion system, Liquid H2 storage, electric power generation, natural gas, Liquid H2 re-fuelling and supply systems, Liquid H2 refuelling systems.

All these disciplines as well as more relevant aspects related to the R&I activity have been traced by dedicated worksheet as well as new energy power sources with low emission.

3.7.2 Advanced aeronautical technology

MW hybrid electric power train, thermal engine, electric motor, cabin noise suppression, electric batteries, sodium-Ion capacitors, hybrid electric energy storage, thermal management system, system integration, sensors and smart sensors, energy converters, avionics cooling, coating and films, ADS-C, additive manufacturing, control systems, automation, remote sensing, H2 combustion system, Liquid H2 engine fuel system, engine integration and controls, dual-fuel systems, H2 tank system, cables/connectors, DC-DC converter, high voltage battery pack, cryo-enabled thermal management system, distributed propulsion system, hybrid water-enhanced turbofan, advanced composite material structures, cabin air supply, conditioning, distribution hybrid electric system cooling, H2 burn (low NOx emission), H/E propulsion and system integration.

3.7.3 New & optimised operational solutions

Several new and ongoing operational solutions, mainly in SESAR framework projects, have been funded to develop new optimised flight control devices, and improvements of operations both on the ground in airport terminal area and at ATS level, to increase the crew's awareness, and to limit their fatigue/stress and preserving the typical high level of safety and security levels of the commercial air transport. These initiatives, with implication on the climate warming, have been selected and grouped to create a related mapping. Several projects have been focused on management activities (e.g.: air traffic management, network management and innovation management). The related main themes, which have been identified are: operation management, planning automation, surface route planning, flight separation management, route planning, automatic collaborative control, trajectory definition, air-to-ground trajectory synchronisation, clearances, OTM Free routing for flight, optimised route network, improve predictability, optimised capacity. A catalogue/dataset has been created, see Appendices D-G.

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3.7.4 Test aircraft and demonstrators

In the last years the R&T approach has been re-thought in order to create a more integrated approach by means of activities devoted to develop Innovative Architectures (Arch). The architectural concepts are suitable to include on a common flight platform the more promising technological solutions and airframe concepts. In this context, referring to specific aircraft categories, several initiatives have been funded to support a coordinate effort to implement the identified solutions in these new concepts. Including also relevant opportunities related to advanced sub-systems and/or devices. The performed survey has identified e.g. the next: SMR architecture, HER architecture, SMR Open-Fan engine architecture, integrated high voltage electrical distribution, primary and secondary power distributions, ultra-efficient airframe, hydrogen enabled integrated airframe (e.g. Hydrogen for Aviation (H2Av)), innovative wing architecture, innovative fuselage and empennages.

The more relevant new air transport platforms or concepts are related to the next vehicle categories: electric vehicles, autonomous vehicles, hydrogen propelled concept, drones, SAF propelled concepts, ultra-performance wing, integrated HAR SAF wing, UERA and HERA concepts (Twin engine and Distributed propulsion), Liquid H2 - SMR concept and SAF - SMR concept. Some of them will be validated by with full scale demonstrator reproducing the relevant operation environment like Very Large Demonstrators (VLD). A list of the test aircraft, demonstrators and infrastructures is provided in Appendix F.

3.7.5 Innovative industrial processes

The creation of electric production facilities in airport unused area supports the pathway towards climate neutrality. The standard airports have in many cases large extensive lands free of natural and artificial obstacles, from tens to hundreds of acres around them. Part of them are usable without risk for the flight activity (departure and arrivals). This circumstance has been exploited, in a growing number of cases, to generate significant level of electric power by means of solar panels. There, this energy could be used as supply for the airport and related service needs at ATM and ground level or surrounding settlements. Such, several initiatives have challenging targets able to assure very large energy coverage e.g. up to 100% as well as for Newcastle airport[2], Chattanooga Metropolitan airport[3] and Hawkes Bay airport[4] (New Zealand). Other relevant opportunities are: recycling, waste treatment processes, biomasses for a sustainable economy adopting new eco-systems, bio-fuels and ecology-based approaches assuring circularity in aviation.

3.7.6 Possible synergies from other industrial sectors

The main relevant initiatives identified referring to the transversal and synergic sectors are: big data, artificial intelligence, data processing, machine learning, deep learning, system

[2] https://www.newcastleairport.com/about-your-airport/environment/solar-farm/
[3] https://www.chattairport.com/solar-farm ; https://indsolarfarm.com/
[4] https://hawkesbay-airport.co.nz/about/sustainability/sustainability-solar-farm-project/

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learning, computational intelligence, open databases, software, business models, Internet of Things (IoT), automotive, transversal promotion, multi-sector cooperation.

3.8 Knowledge gaps affecting anthropogenic climate impacts

3.8.1 Existing gaps

Despite the effort made in the numerous initiatives dedicated to characterising the effects of human activities on the evolution of the Earth's climate, we realize that the exact determination of the correlation between emissions from air transport and the relative contribution to the variation in temperatures is far from being resolved with an acceptable degree of accuracy. The combined action of a vast number of independent parameters at the same time, often linked together, affects heavily the climate phenomena and determines the need to govern a vast number of disciplines: e.g. chemistry, physics, climatology, science of earth, astronomy, astrophysics, oceanography, meteorology, kinetics of rarefied gases, thermodynamics, photo-chemistry etc. Being able to coordinate a so enormous amount of data and relationships involved in cause-effect links, which are not entirely recognised, is a huge task. Additionally, the hidden presence of cross-contributions may either be mistakenly attributed or overlooked, owing to their complexity, which makes them difficult to detect using simple analytical tools, or due to underlying assumptions. Furthermore, even if a model is developed to describe observations with the highest possible accuracy, in most cases, we encounter an expansion of uncertainty bands. This gives rise to serious doubts about the descriptive effectiveness of such a constructed prediction. In other words, the model could not be able to reconstruct the essence of the different interacting phenomena. It is important to consider that such an overlap of the various apparently chaotic variables suggests, or rather imposes, the adoption of statistics as an indispensable tool for evaluating the different contributions. This brings the possibility to identify the real effects induced by human activities referring to the natural ones.

3.8.2 Possible gaps mitigation initiatives

One of the relevant goals for CLAIM is to identify the most relevant technology innovations, the optimised operational solutions and ATS effective procedures able to concur to mitigate the climate warming and to air quality around the airport areas. In this framework a vast activity has been developed and implemented to identify the relevant projects able to affect with their innovations the environmental impact, limiting the GHG emissions of the air transport in atmosphere. The developed methodology has been followed to identify and select groups of projects in relation to their focused activity with a special attention also to the new concepts like Short and Medium Range (SMR) and Hybrid Electric Regional (HER). The analysis has been extended to identification and characterization of the advanced and purpose-built research concepts/facilities providing a formatted synthetic description in tabular form and included the consulted data source references. Moreover, the demonstrators adopted in order to verify the impact effectiveness and validate the activities performed in the CA framework programme, have been identified. Activities devoted to explore the emission mitigation, operational efficiency, scalability of the propulsive powertrain, the improvement of the air transport efficiency, as well as possible synergies were collected. This includes details

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referring to development of technologies, methods or tools related to aerodynamics, structural analysis, propulsion systems.

3.9 Results

A methodological approach has been developed (see section 3.6) for mapping the recent and on-going initiatives that influence the environmental impact from air transport. A multi-step survey has been performed to identify the more relevant projects funded at European and national levels, in relation to climate change. In relation to the innovative technological and/or operational solutions proposed in Appendix D. These tables reports the selected projects, a related short description, a progressive index and includes the related framework programme and data source reference (e.g. Cordis website, SESAR or project website). The project description is based on different worksheets. The first, Table 3 in Appendix D provides, for each project considered of interest for CLAIM, a synthetic tabulated description with reference to the CLAIM main topics, which are focused on the aircraft concepts "Hybrid-Electric" (HE), "Hydrogen for Aviation" (H2Av) and "More Electric" (MorE). Moreover, CLAIM aspects which have been considered are: "Architecture" (Arch), "Technology" (Techno), "Assessment" (Assess) and "Concept" (Cnpc), for sake of completeness, while, a further group has been devoted to clarify the existing connection to activity or categories like: "Industrial processes" (IndPrc), "Operation" (Opr), "Validation Tasks" (ValTsk) "Demonstration" (Demo), "Electric Vehicle-Test Aircraft" (EV-TA), "Transversal and coordination actions" (Transv) and the "Advanced and/or Disruptive Aircraft Concept". (A&DAC). The worksheet: “ScienceApp” collects the observed elements and characteristics descriptive of the performed or ongoing activities. They have been classified and used to assure the clear identification of the applicable scientific area or discipline and sorted referring to the possible theme type. Obviously, that has been done taking into account, as soon as possible, the shared general public assumptions (e.g. acronyms, targets, topics, categories, etc). A portion of this last worksheet has been devoted to describe the identified connection among the scientific application areas and the themes of the reference roadmaps. The “Reference” worksheet provided the project data source references in tabular format suitable for an easy integration into the dedicated annex of the present outcome. A very central role is performed by the “Analysis” worksheet. This worksheet assures in a single common table the identification of the existing link among the reference roadmaps interested to one or more of the next themes: “Technologies”, “Operations”, “Alternative Fuels”, “Market based measures” and the added “Others” vs the applicative sciences, or themes referring to the projects with applicable actions in such item.

3.10 Conclusions

A catalogue of R&T projects has been created in order to collect interesting projects focused on advanced technologies, innovative manufacturing processes, disruptive aircraft architectural concepts and optimised solutions referring to the possible impact on climate warming, air quality as well as involved scientific areas and transversal initiatives. Several different themes have been considered and traced to support the environmental impact assessment in line with the driver parameters of the involved phenomena. Moreover, a list of

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the test aircraft, demonstrators and new infrastructures has been included to characterize the recent and on-going initiatives devoted to validate the robustness of the possible impacts and benefits and to support the development of a competitive Air Transport (AT) system in Europe.

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APPENDIX A: CATEGORISATION

Study context

A distinction was made whether the aircraft concept was developed in a research project, in another paper/parametric study or as a commercial concept.

Aircraft class

The options are commuter aircraft (with 19 seats), regional aircraft (range up to 1000nm), short/medium range aircraft (range of 1000nm-3000nm) and long-range aircraft (range above 3000nm). The categorisation is determined according to the information in the reference and otherwise based on the (design) range.

Aircraft architecture

Conventional

A conventional aircraft architecture is referred to as a tube-and-wing configuration where the fuselage is shaped as a cylinder and wings are attached to the body. The wing can either be mounted in a low-wing, mid-wing or high-wing configuration. Different empennage configurations such as a standard fuselage mounted tails or a T-tail are also considered to be conventional.

Canard

A canard configuration has a fuselage mounted horizontal lifting surface (wing) located ahead of the main wing. The canard can enhance lift production, pitch control during manoeuvring, longitudinal stability and trim or control on the main wing airflow.

Blended wing body/hybrid wing

A blended wing body (BWB) or hybrid wing is an aircraft design configuration, where the fuselage body structure and wings are smoothly integrated together to form a single structure. There is no discrete fuselage body or empennage. This design reduces the drag from the wing-body junction as seen in conventional tube-and-wing aircraft. Furthermore, the entire body is lift generating, allowing for smaller sized outer wings.

Flying V

The Flying V is an aircraft design concept which integrates the passenger cabin, cargo hold and fuel tanks in the wings, creating a V-shaped body. The body shape leads to increased aerodynamic performance and reduced weight.

Strut-/truss-braced wing

A strut-braced or a truss-braced wing is an aircraft design configuration with extra-long, thin wings which are stabilised by diagonal struts or trusses at the mid-span. This configuration

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allows for higher aspect ratio wings with reduced induced drag. The strut-braced wing can result in reduced wing weight at a given aspect ratio.

Box wing

The box wing aircraft configuration features a closed wing-system with two main wings which are connected by side panels or side wings. The box-wing maximises the wing span efficiency and therefore achieves minimum induced drag for a given span and weight.

Double bubble

The double bubble aircraft design features a fuselage shape that fuses two fuselage tubes/bubbles smoothly together. This fuselage design generates an increased amount of lift and a positive pitching moment during cruise, allowing for smaller wing and horizontal tail designs and therefore reducing the aircraft weight and drag.

Energy carrier

The considered energy carriers are kerosene, batteries, hydrogen (either used in a fuel cell or directly combusted), sustainable aviation fuel (SAF) or liquid natural gas (LNG).

Propulsion concepts

The aircraft concepts can use conventional turbofans, conventional turboprops, innovative turbofans (which are not further specified, but e.g. efficiency improvements are assumed), innovative turboprops (which are not further specified, but e.g. efficiency improvements are assumed). Ultra-high bypass ratio (UHBR) engines aim to improve fuel efficiency with a higher bypass ratio, meaning that a larger portion of the incoming air is accelerated by the fan and not passing the core (consisting of the compressor, combustion chamber and turbine) of the jet engine. Other disruptive propulsions concepts are the following:

Unducted fan engine/Open rotor/Propfan

An unducted fan engine, also referred to as an open rotor or propfan, is a type of engine that uses multiple blades to generate thrust without a surrounding duct or casing. Typically, open rotor designs have two sets of fan blades placed after each other. The blades are swept back and heavily twisted. In some designs the blades twist in opposite direction to the front ones and form counter-rotating blades. In other designs, the set of blades are non-rotating and act as variable pitch stator to help flow recovery. The open rotor combines the fuel efficiency of a turboprop with the speed and performance of a turbofan.

Boundary layer ingestion engine

Boundary layer ingestion (BLI) is an aero propulsive design concept in which the engine ingests the boundary layer. Due to friction between the air and the aircraft skin, a layer with retarded air is developed over the fuselage (and/or wing). In BLI design, the engine ingests this boundary layer and the air is accelerated by the fan or propeller, reducing the drag and increasing the aircraft efficiency. Propulsors which make use of BLI can generate propulsive

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force with less power input due to reduced jet, surface and wake dissipation. However, the variation in ingested flow speeds (flow distortion) could pose challenges to the engine design.

Embedded engines

Embedded engines are mounted inside the aircraft's fuselage or within the wing, rather than being attached to the wing or fuselage with pylons. This design approach can provide improved aerodynamics, reduced drag, and increased fuel efficiency, but can also present cooling and maintenance challenges.

Hybrid-electric turbofan / turboprop

A hybrid electric turbofan or hybrid electric turboprop is a type of aircraft powertrain that combines a turbofan engine with electric motors. There are several architectures. The parallel hybrid powertrain combines the power of the turbine engine and electric motor to drive the propeller or fan, with the electric motor powered by for example a battery or fuel cell. In a series hybrid powertrain, the turbine engine drives a generator which produces electricity. The electric power from the generator, supplemented by power from a battery or fuel cell, is used to power the electric motor. The electric motor alone drives the propeller or fan. Lastly, a turboelectric architectures features a turbine engine that solely drives a generator, producing electricity that is directly used to power the electric motor which is driving the propeller or fan. Furthermore, other architectures exist that combine elements of the above mentioned hybrid architectures, such as partially turboelectric and series/parallel hybrid electric configurations.

Distributed electric propulsion

Distributed electric propulsion (DEP) is an aeropropulsive design concept which utilises multiple electrically-driven propulsors to propel the aircraft. The propulsors are placed with larger flexibility and enable beneficial aero-propulsive coupling, such as increased dynamic pressure across the blown surfaces for increased lift performance. Furthermore, DEP can be used for vehicle control, therefore reducing the requirements for traditional control surfaces and increasing the system’s ability to adapt to critical one-engine inoperative scenarios. A concept with more than 4 electrically driven propellers is considered as distributed electric propulsion in this study.

Aerodynamic concepts

Laminar flow wing

Airflow over the aircraft wing typically transitions from a smooth/laminar state near the leading edge to a turbulent state towards the trailing edge. This occurs due to frictional interactions between the air and the wing’s surface. The goal of a laminar flow wing is to achieve uniform laminar flow across the entire wing surface. This results in reduced aerodynamic drag and fuel consumption. One possible way is utilising forward-swept wings so that the aircraft can benefit from delayed cross-instabilities and attachment line transition, allowing natural laminar flow to be maintained at higher cruise speeds and therefore leading to increased cruise efficiency. Furthermore, reduced surface roughness, optimised wing and airfoil shape design can contribute to maintaining natural laminar flow longer.

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Riblets

A riblet is a passive drag reduction device consisting of streamwise grooved surfaces. The small triangular-shaped protrusions or grooves are aligned in the direction of the airflow. Riblets reduce friction drag in the turbulent part of the airflow, as they modify the turbulence structures of the boundary layer, making it more stable and less prone to separation.

(Hybrid) laminar flow control

Laminar flow control refers to the use of active systems to control and manipulate the boundary layer on an aircraft's surface. The goal of laminar flow control is to delay the transition from laminar to turbulent flow and thus reducing drag and increasing aircraft efficiency. Options for laminar flow control are cooling the surface wall or using suction slots. Laminar flow control can be used in combination with natural laminar flow technology, which is known as hybrid laminar flow control.

High Aspect Ratio Wing

High aspect ratio wings are long and slender wings. This wing shape generates less vortex-induced downwash, leading to less induced drag and therefore better fuel efficiency. Advances in material science make it possible to design and build high aspect ratio wings that are both strong and lightweight.

Winglets/wing tips

Wingtips are aerodynamic devices at the end of an aircraft's wing. Folding/morphing wing tips, advanced wing tip devices and multi-winglet system are considered.

Other aerodynamic technologies

Other aerodynamic technologies identified in Deliverable D3.1 did not occur often on the aircraft concepts. An explanation is that the aircraft concepts are more high level, and these technologies would follow in the detailed aircraft design phase. These technologies are: Aeroelastic tailoring, Adaptive compliant trailing edge, variable camber wing, flaplets, hingeless/morphing flap.

Structural concepts

Composite materials

Composites, such as carbon fibre reinforced polymers, are lightweight materials used to reduce weight and increase stiffness and strength, depending on the design.

Dry wing

A dry wing is a wing design that does not store fuel in the wing itself, leaving space for other structural components or systems or allowing for a sleeker wing design.

Other structural technologies

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Other structural technologies identified in Deliverable D3.1 did not occur often on the aircraft concepts. An explanation is that the aircraft concepts are more high level, and these technologies would follow in the detailed aircraft design phase. These technologies are: Low weight landing gear system, multi-functional cryogenic/high temperature, morphing materials, anticontamination surface coating, light weight aerogel structures, transparent panels, windowless design

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APPENDIX B: OVERVIEW OF INVESTIGATED AIRCRAFT CONCEPTS

Table 2: Overview of investigated aircraft concepts in Chapter 2

Concept	Developed by	Study context	Related research projects	Year
TW98 - DD	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
OWN98 - DD	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
TW160 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
OWN160 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
TW216 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
HWB216 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
TW301-DD	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
TW301-GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
HWB301-DD	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
HWB301-GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
MFN301 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
TW400 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
HWB400 - GTF	NASA	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2016
LH Box Wing	Lockheed Martin	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2011
NG T+W 2025	Northrop Grumman, Rolls-Royce, Wyle Laboratories, Iowa State Univ.	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2011
NG - Flying Wing	Northrop Grumman, Rolls-Royce, Wyle Laboratories, Iowa State Univ.	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2011
Ascent 1000	DZYNE	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2018
BWB-165	DZYNE	research project	ERA Environmentally Responsible Aviation (NASA N+2)	2018
SUGAR Refined	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2011

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SUGAR High Phase I	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2011
SUGAR Ray	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2011
SUGAR Volt Phase I	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2011
SUGAR Super Refined	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2015
SUGAR Volt Ph. II "Balanced"	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3 hybrid electric	2015
SUGAR Volt Ph. II "Core shutdown"	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3 hybrid electric	2015
SUGAR Electric Eel	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3 hybrid electric	2015
SUGAR Sting Ray	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3 hybrid electric	2015
SUGAR High Phase III	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+3	2020
N3-X	NASA	research project	NASA N+3	2015
SELECT	Northrop Grumman, Rolls-Royce, Sensis, Tufts Univ., Spirit Aerosystems	research project	NASA N+3	2010
H3.2	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
D8.1 Al	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
D8.5 Comp	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
SD8.1 Al	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
SD8.5 Comp	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
D8.6	MIT, Aurora, Pratt&Whitney	research project	NASA N+3	2010
D8 Aurora-2016	Aurora	research project	NASA N+3	2017
D8 Aurora-2035	Aurora	research project	NASA N+3	2017
GE/Cessna	GE, Cessna, Georgia institude of technology	research project	NASA N+3	2010
TBW-XN	NASA, NIA, Virginia Tech, Georgia Tech	research project	NASA N+3	2010
N+4 Refined SUGAR	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015
N+4 SUGAR High	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015
SUGAR Freeze	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015
SUGAR Freeze UDF	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015
SUGAR Freeze hybrid BLI	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015

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SUGAR Freeze hybrid UDF	Boeing, General Electric, Georgia Institute of Technology	research project	NASA N+4	2015
AHEAD - LH2	TU Delft, DLR	research project	AHEAD	2016
AHEAD - LNG	TU Delft, DLR	research project	AHEAD	2016
iE	Bauhaus Luftfahrt, Aristotle Univ. of Thessaloniki	research project	ULTIMATE	2017
IC	Bauhaus Luftfahrt, Aristotle Univ. of Thessaloniki	research project	ULTIMATE	2017
PFC	Bauhaus Luftfahrt, CIAM, ONERA, Airbus	research project	DisPURSAL	2015
Hybrid PFC	Bauhaus Luftfahrt, CIAM, ONERA, Airbus	research project	DisPURSAL	2016
DMFC	Bauhaus Luftfahrt, CIAM, ONERA, Airbus	research project	DisPURSAL	2017
Hybrid DMFC	Bauhaus Luftfahrt, CIAM, ONERA, Airbus	research project	DisPURSAL	2018
PFC	Bauhaus Luftfahrt, Airbus, Chalmers, MTU, Rolls-Royce, Siemens, TU Delft, Univ. Cambridge, ARTTIC, Politechnika Warszawa	research project	CENTRELINE	2020
PRP-186	Univ. of Pisa, TU Delft, ONERA, DLR, ENSAM, SkyBox Engineering	research project	PARSIFAL	2020
PrP-240	Univ. of Pisa, TU Delft, ONERA, DLR, ENSAM, SkyBox Engineering	research project	PARSIFAL	2020
PrP-MS1.2 (PrP-300)	Univ. of Pisa, TU Delft, ONERA, DLR, ENSAM, SkyBox Engineering	research project	PARSIFAL	2020
PrP-MSx	Univ. of Pisa, TU Delft, ONERA, DLR, ENSAM, SkyBox Engineering	research project	PARSIFAL	2020
REG-CON	Bauhaus Luftfahrt	research project	IMOTHEP	2023
REG-RAD	DLR	research project	IMOTHEP	2022
SMR-0HEP	NLR	research project	IMOTHEP	2024
SMR-RAD	NLR	research project	IMOTHEP	2024
SMR-CON (DRAGON)	ONERA	research project	IMOTHEP	2024
2050 T&W Jet A-1 SMR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
2050 T&W Biofuel SMR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
2050 T&W LNG SMR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
Lower Risk LH2 SMR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace,	research project	ENABLEH2	2023

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	SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC			
Cobalt Blue 2	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
2050 T&W Jet A-1 LR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
2050 T&W Biofuel LR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
2050 T&W LNG LR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
Lower Risk LH2 LR	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
BWB LNG	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
EH2 BWB (Synergy LH2 LR)	Cranfield Univ., Chalmers Univ., London South Bank Univ., GKN Aerospace, SAFRAN, Energy and Hydrogen Alliance, Heathrow Airport, ARTTIC	research project	ENABLEH2	2023
FUTPRINT50 CO2 neutr. config.	Univ. Stuttgart, Cranfield Univ., Airholding, TU Delft, ADSE, CEA, EASN, Univ. Telematica Unicusano, Embraer	research project	FUTPRINT50 (H2020)	2023
FUTPRINT50 zero em. config.	Univ. Stuttgart, Cranfield Univ., Airholding, TU Delft, ADSE, CEA, EASN, Univ. Telematica Unicusano, Embraer	research project	FUTPRINT50 (H2020)	2023
PHA2-TipProp	DLR	research project	Large Passenger Aircraft (LPA)	2017
LPA with distr. ducted el. fans	ONERA, ISAE SUPAERO	research project	Large Passenger Aircraft (LPA)	2018
BTF - DLR	DLR	research project	ADEC, Large Passenger Aircraft (LPA)	2020
BLI-Canard	DLR	research project	ADEC, Large Passenger Aircraft (LPA)	2020
BLI-WingFans	DLR	research project	ADEC, Large Passenger Aircraft (LPA)	2020

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BLI-ETF	DLR	research project	ADEC, Large Passenger Aircraft (LPA)	2020
ADEC DRAGON	ONERA	research project	ADEC, Large Passenger Aircraft (LPA)	2020
NOVAIR LE DEP	TU Delft	research project	NOVAIR, Large Passenger Aircraft (LPA)	2020
NOVAIR Tip mounted	TU Delft	research project	NOVAIR, Large Passenger Aircraft (LPA)	2020
NOVAIR BLI Fan	TU Delft	research project	NOVAIR, Large Passenger Aircraft (LPA)	2020
NOVAIR BTF - NLR	NLR	research project	NOVAIR, Large Passenger Aircraft (LPA)	2020
SMILE BWB	ONERA	research project	NACOR, baseline for IMOTHEP	2022
C7A	Pipistrel, Politecnico di Milano, TU Delft	research project	UNIFIER19	2021
TRANSCEND Regional	NLR	research project	TRANSCEND	2022
TRANSCEND SMR single	NLR	research project	TRANSCEND	2022
TRANSCEND SMR twin	NLR	research project	TRANSCEND	2022
GLOWOPT ATR100 optimised	TUHH, TU Delft	research project	GLOWOPT	2022
GLOWOPT truss-braced	TUHH, TU Delft	research project	GLOWOPT	2022
GLOWOPT turboprop	TUHH, TU Delft	research project	GLOWOPT	2022
GLOWOPT red. design range	TUHH, TU Delft	research project	GLOWOPT	2022
GLOWOPT - single-aisle	TU Delft	research project	GLOWOPT	2022
Cantilever concept	ONERA, TU Delft, Univ. Stuttgart	research project	UP Wing	2024
Strut-braced dry wing	ONERA, TU Delft, Univ. Stuttgart	research project	UP Wing	2024
Flying V	TU Delft	research project	Flying V	2014
TuLam	DLR	research project	TuLam	2019
CoCoRe	DLR, Bauhaus Luftfahrt	research project	CoCoRe	2020
SynergIE	DLR, Airbus, Rolls-Royce, Bauhaus Luftfahrt	research project	SynergIE	2021
KuuL UHBR long	DLR	research project	KuuL	2023
D325+ Kerosene	DLR	research project	KuuL	2024
D325+ SAF	DLR	research project	KuuL	2024
D325+ LH2	DLR	research project	KuuL	2024
DLR-F25	DLR	research project	LuFo VI-2 VirEnfREI	2024
EXACT MHEP	DLR	research project	EXACT	2022
EXACT Plug-In Concept	DLR	research project	EXACT	2024
EXACT Turboprop	DLR	research project	EXACT	2024
EXACT Turbofan	DLR	research project	EXACT	2024
ALBATROS	ONERA	research project	ALBATROS	2012
NOVA	ONERA	research project	NOVA	2015
CICAV	ONERA	research project	CICAV	2019
Gullhyver	ONERA	research project	Gullhyver	2023

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FZR-1E	FlyZero/ATI	research project	FlyZero	2022
FZN-1E	Flyzero/ATI	research project	FlyZero	2022
FZN-1G	Flyzero/ATI	research project	FlyZero	2022
Wake Adaptive Thruster (WAT) concept / ECLAIR (Electrification Challenge for Aircraft)	JAXA	research project	MEGAWATT / ECLAIR	
TRA 2022	JAXA	research project	ECAT (Environment Conscious Aircraft Technology R&D Program	2012
Hydrogen e-Hybrid	JAXA	research project		
Hydrogen BWB	JAXA	research project		
STARC-ABL	NASA	research project	NASA Advanced Air Transport Technology (AATT) project	2016
PEGASUS	NASA	research project	NASA Advanced Air Transport Technology (AATT) project	2017
PEGASUS 1.0	NASA	research project	NASA Advanced Air Transport Technology (AATT) project	2019
PEGASUS 2.0	NASA	research project	NASA Advanced Air Transport Technology (AATT) project	2024
Fuel-battery hybr. narrow-body	Safran, MTU Aero Engines, Bauhaus Luftfahrt	other paper / parametric study		2014
S1	TU Delft	other paper / parametric study		2016
S2	TU Delft	other paper / parametric study		2016
hybrid-elec. reg. TP aircraft	TU Delft	other paper / parametric study		2017
BHL Quad-Fan	Bauhaus Luftfahrt (Pornet, Iskiveren)	other paper / parametric study		2015
PGT070 2GT+1M	Safran, Bauhaus Luftfahrt, Munich Aerospace	other paper / parametric study		2016
PGT180 2GT+1M	Safran, Bauhaus Luftfahrt, Munich Aerospace	other paper / parametric study		2016
ZEROe turboprop	Airbus	commerical		2020
ZEROe Turbofan	Airbus	commerical		2020
ZEROe BWB	Airbus	commerical		2020
ZEROe "Pod" config.	Airbus	commerical		2020
Bird of prey	Airbus	commerical		2019
E-Thrust / DEAP	Airbus, Rolls-Royce, Cranfield Univ.	commerical		2012
E19-HE	Embraer	commerical	Energia concepts	2023
E30-HE	Embraer	commerical	Energia concepts	2023
E50-HE	Embraer	commerical	Energia concepts	2023
E19-H2FC	Embraer	commerical	Energia concepts	2023
E30-H2FC	Embraer	commerical	Energia concepts	2023
E50-H2FC	Embraer	commerical	Energia concepts	2023
E50-H2GT/DF	Embraer	commerical	Energia concepts	2023
EVO Concept	ATR	commerical		2022
ATL-100H	magniX, Desaer	commerical		2020

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ES-30	Heart Aerospace	commerical		2019
Miniliner	Pipistrel	commerical		2021
HERA	EAG (electric aviation group), Jet Zero consortium	commerical		2017
H2ERA	EAG (electric aviation group), Jet Zero consortium	commerical	H2ERA program	2020
NextGen	GKN Fokker	commerical		2023
hydrogen DHC-8-400	ZeroAvia, De Havilland Canada	commerical		2021
Aura Aero ERA	Aura Aero	commerical		2021
Eco Otter	Ampaire	commerical		2021
UH Regional retrofit	Universal Hydrogen	commerical		bankrupt
Maeve M80	Maeve Aerospace	commerical		2024
ECO-150-300	ESAero (Empirical Systems Aerospace), NASA	commerical		2019
BEHA MH1	Faradair Aerospace	commerical		2014
DAX-19	Dante AeroNautical	commerical		2021

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APPENDIX C: ENVIRONMENTAL PERFORMANCE HEAT MAP ANALYSIS

Kerosene fuel burn

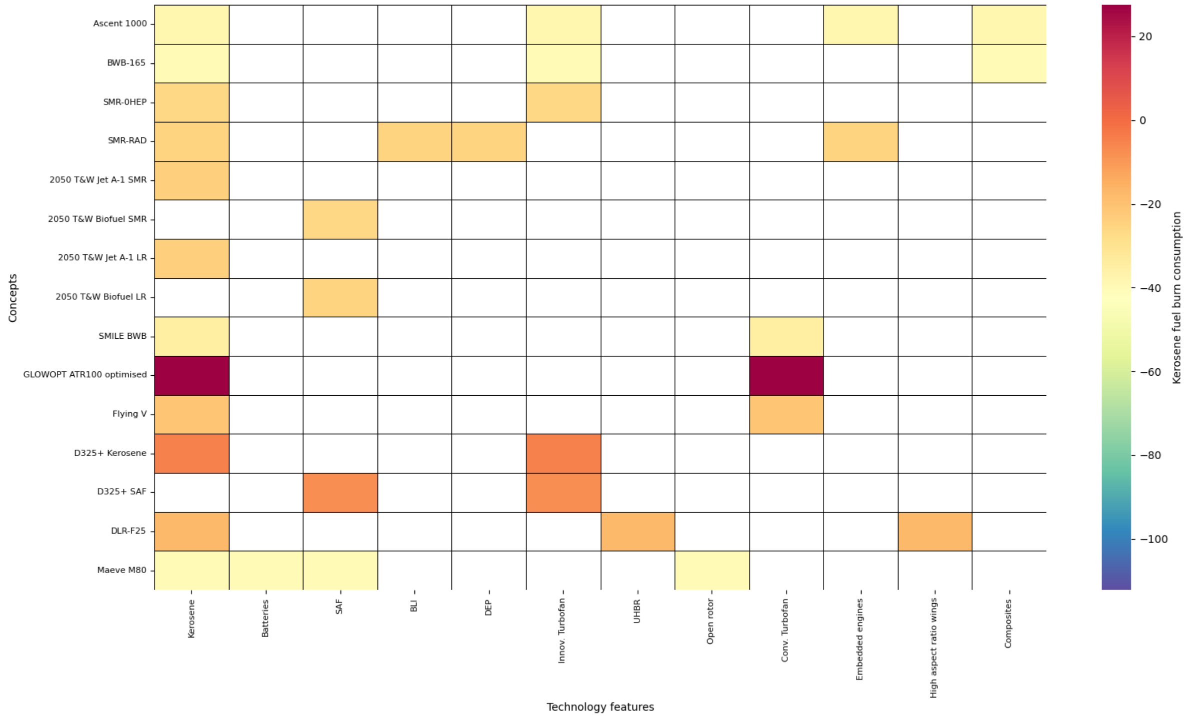

Figure 16: Heat map technology features effect on kerosene fuel burn consumption compared to state-of-the-art reference aircraft

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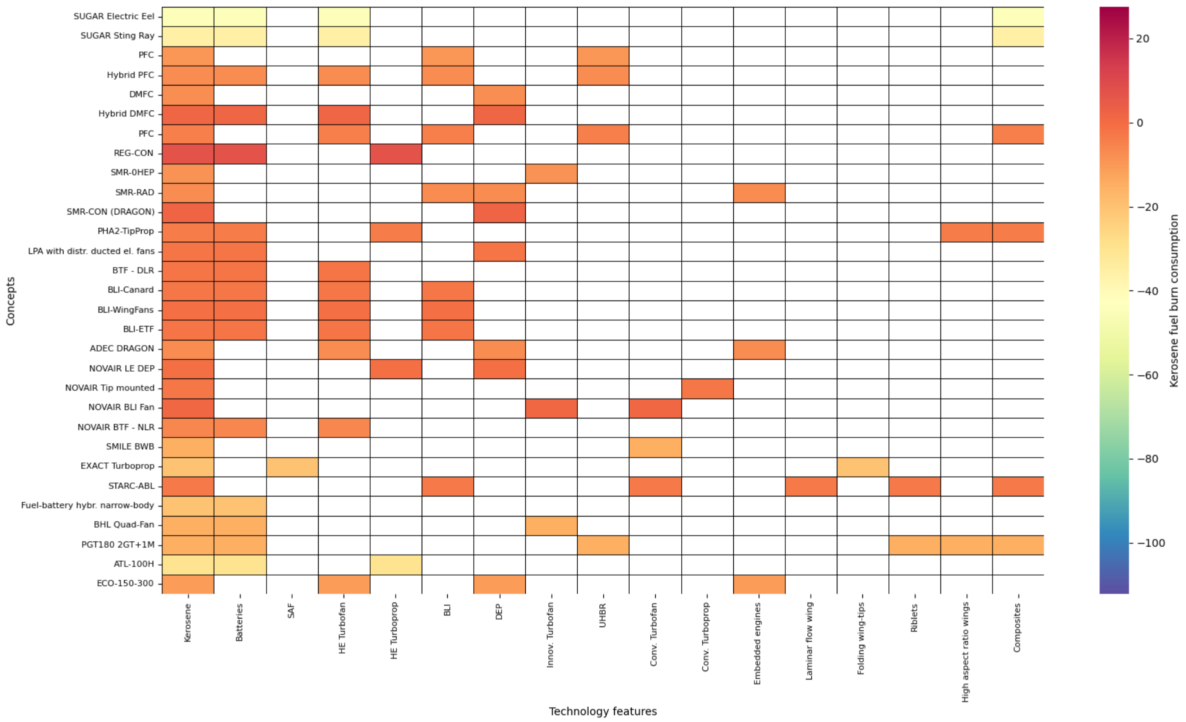

Figure 17: Heat map technology features effect on kerosene fuel burn consumption compared to future reference aircraft

CO_2 reduction

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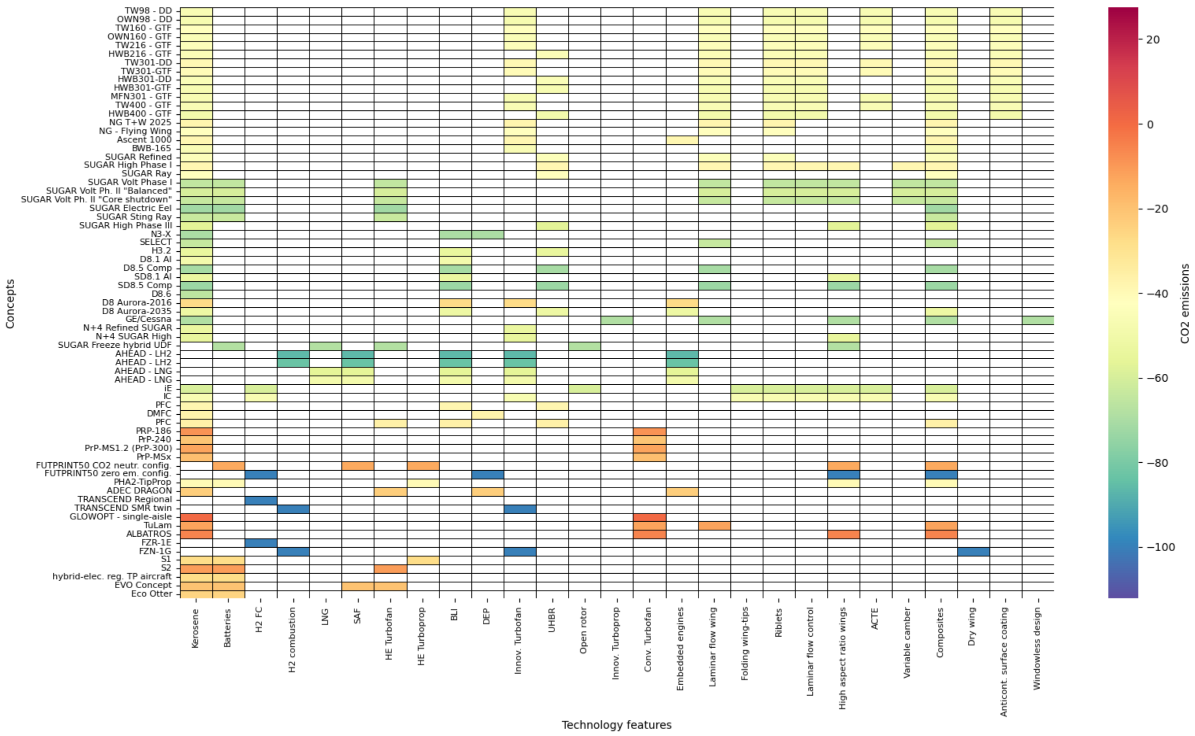

Figure 18: Heat map technology features effect on CO_2 emissions compared to traditional reference aircraft

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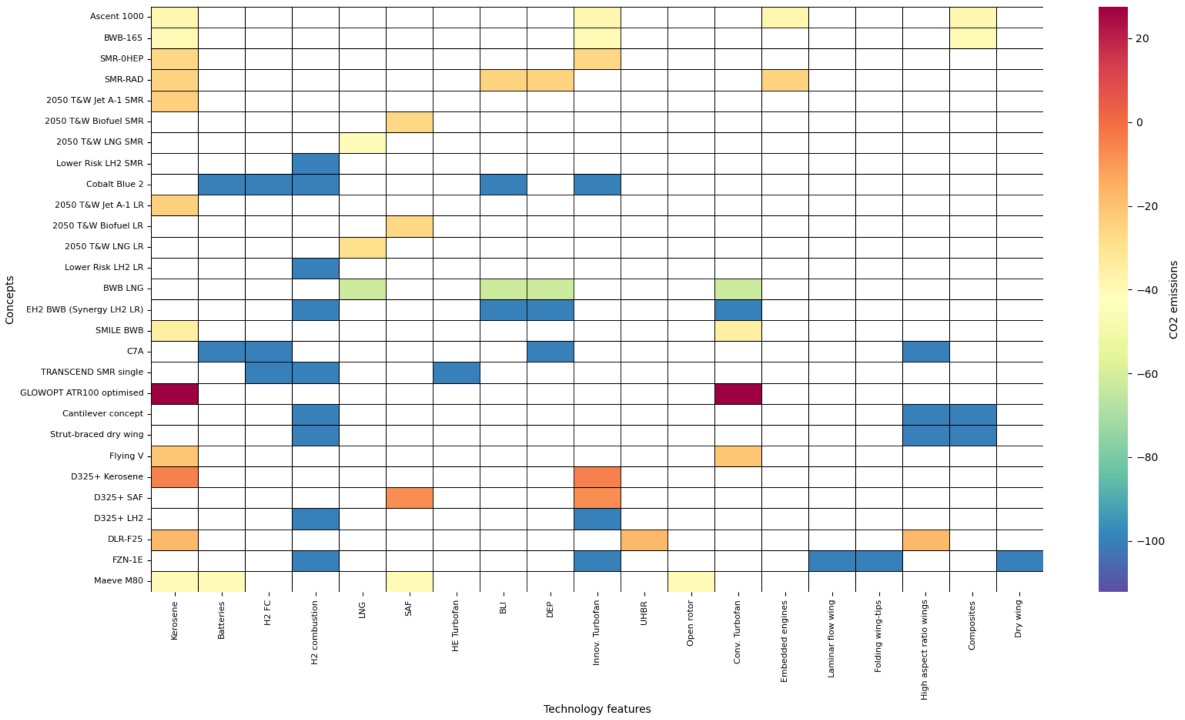

Figure 19: Heat map technology features effect on CO_2 emissions compared to state-of-the-art reference aircraft

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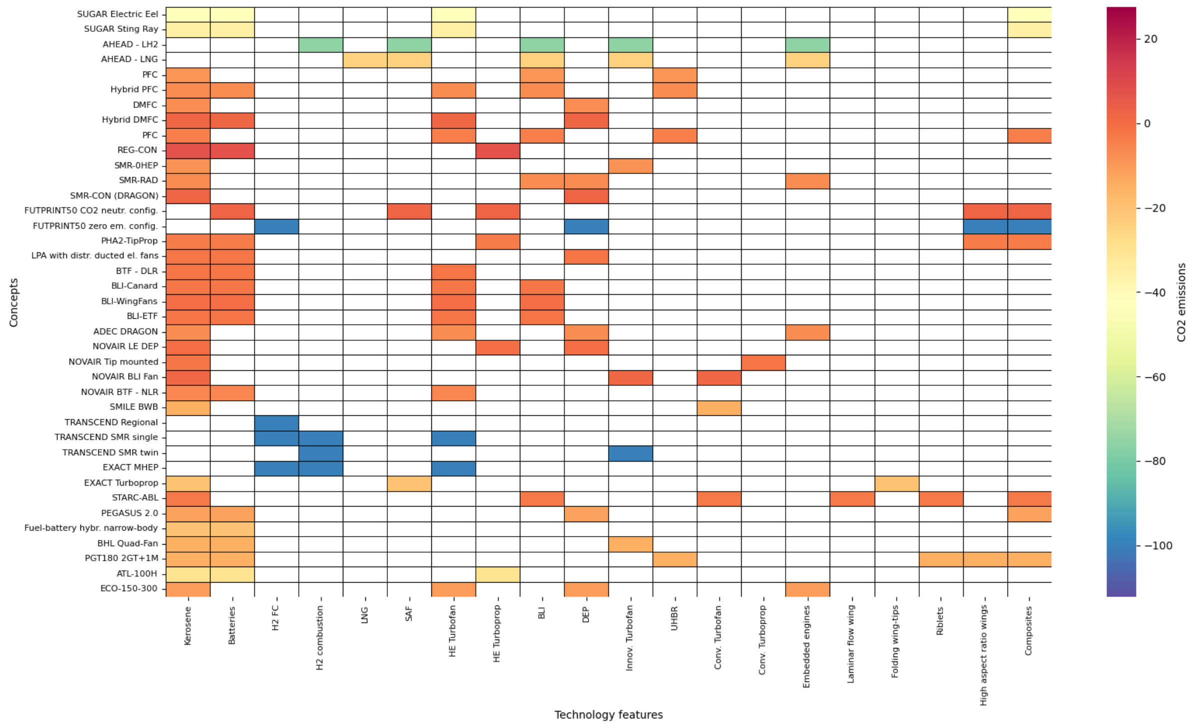

Figure 20: Heat map technology features effect on CO_2 emissions compared to future reference aircraft

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NO_X reduction

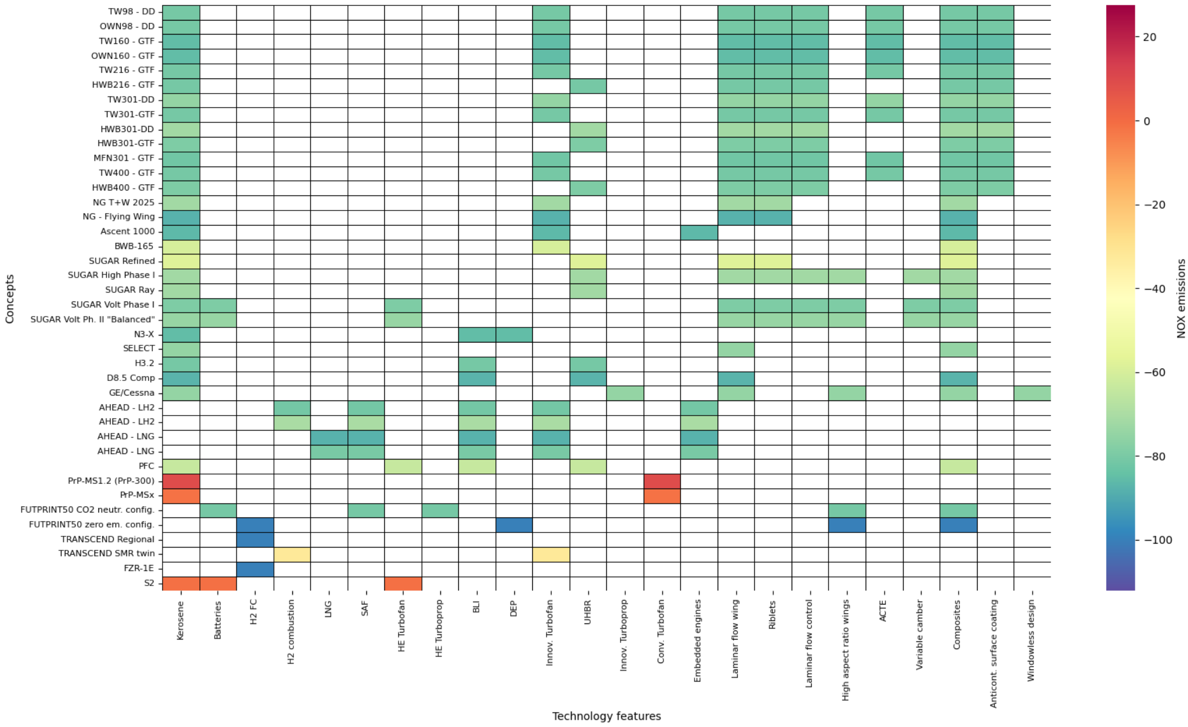

Figure 21: Heat map technology features effect on NO_X emissions compared to traditional reference aircraft

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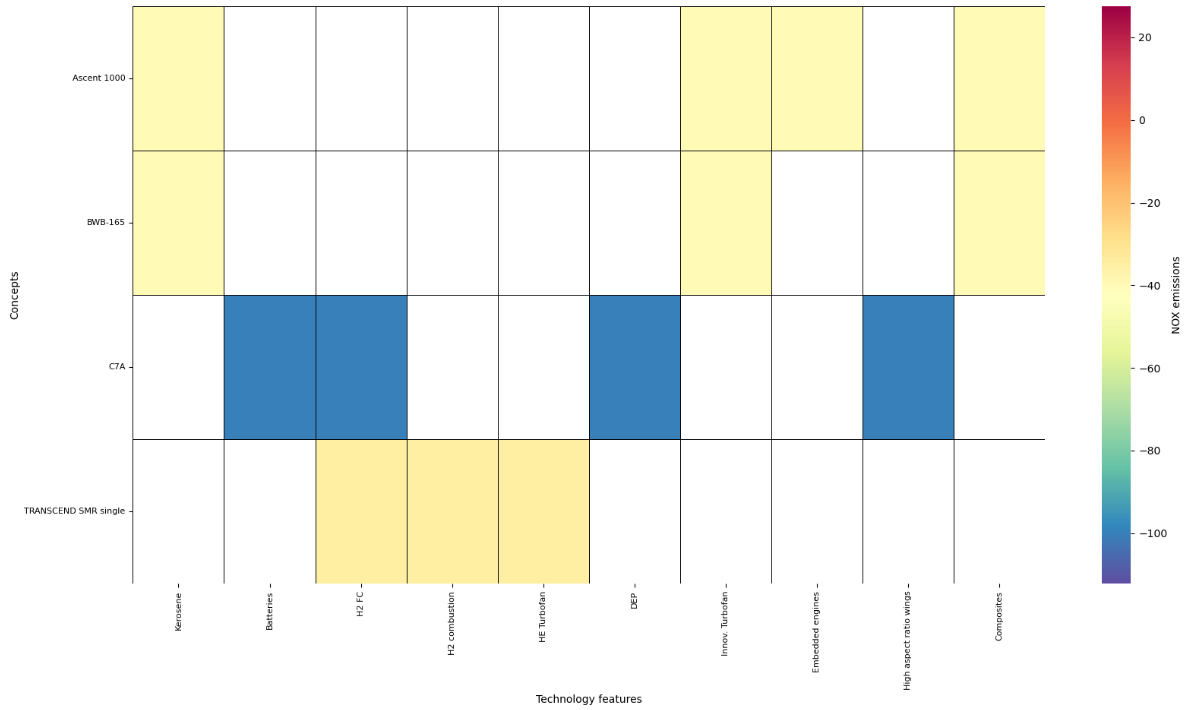

Figure 22: Heat map technology features effect on NO_X emissions compared to state-of-the-art reference aircraft

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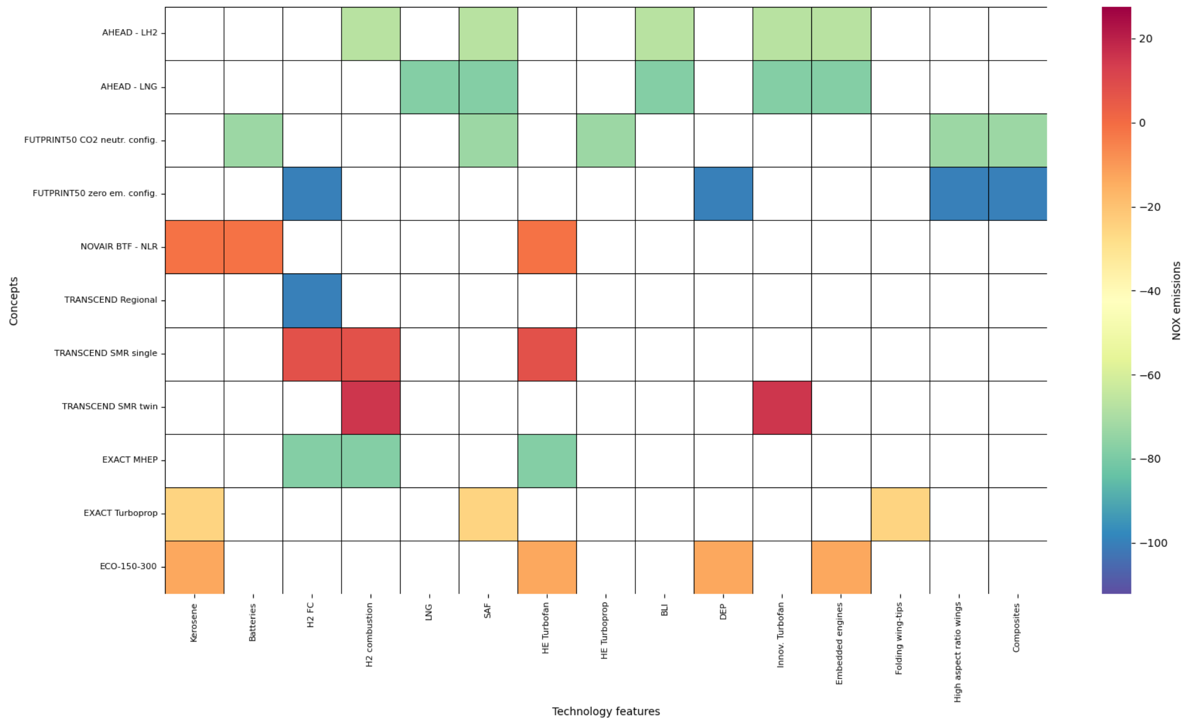

Figure 23: Heat map technology features effect on NO_X emissions compared to future reference aircraft

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APPENDIX D: R&I PROJECTS AND RELEVANT TECHNOLOGIES

Table 3: List of identified R&I projects and relevant technologies

List of identified R&I projects & relevant technologies related to the Aviation climate impact (1/7)

Index	Project	Description	Ref.
1	3beLiEVe	Delivering the 3b generation of lnmo cells for the xev market of 2025 and beyond	[001]
2	ACACIA	Advancing the Science for Aviation and ClimAte	[002] [156]
3	ADVAGEN	Development of advanced next generation solid-state batteries for electromobility applications	[003]
4	aEro	Future of aviation is electric	[004]
5	AM2SoftMag	Additive manufacturing of amorphous metals for soft magnetics	[005]
6	AMBER	Innovative demonstrator for hybrid-electric regional application	[006] [157]
7	AMU-LED	Enhanced data management techniques for real time logistics planning and scheduling	[007]
8	ASTRABAT	Resilient transport infrastructure to extreme events	[008]
9	ATRA	Aerial transport for remote areas	[009]
10	AUTO-MEA	Automated manufacturing of wound components for next generation electrical machines	[010]
11	BAE	Role of base molecules in aerosol formation	[011]
12	BATNMR	Development and application of new nmr methods for studying interphases and interfaces in batteries	[012]
13	BatWoMan	Carbon neutral eu battery cell production	[013]
14	BeCoM	Better Contrails Mitigation	[014]
15	CarbonNeutralLNG	Truly carbon neutral electricity enhanced synthesis of liquefied natural gas (LNG) from biomass	[015]
16	CAVENDISH	Aero-engine demonstration and aircraft integration strategy with hydrogen	[016]
17	CERISE	CopERnIcus climate change Service Evolution	[017]
18	CETP	Clean energy transition partnership	[018]
19	CHYLA	Credible hybrid electric aircraft	[019] [158]
20	CircoMod	Circular economy modelling for climate change mitigation	[020]
21	CIRCULAIR	Circular fuel supply for air transport via negative emission HTL conversion	[021]
22	CIRRUS-HL	Research campaign on ice clouds in high altitude	[022]

List of identified R&I projects & relevant technologies related to the Aviation climate impact (2/7)

Index	Project	Description	Ref.
23	CLAIM	Clean aviation support for impact monitoring	[023]
24	CLAIRPORT	Clear Sky 2 - Airport Environmental Impact Assessment for fixed-wing aircraft	[024]
25	Clean(S)tack	Automated production process for next-level redox flow battery stacks and modules following a revolutionary different and cost-optimised production approach	[025]
26	Climaviation	Action de recherche sur Aviation et Climat	[026]
27	CLIMOP	Climate assessment of innovative mitigation strategiesd towards operational improvement in aviation	[027]
28	COBRA	Digital method for improved manufacturing of next-generation multifunctional airframe parts	[028]
29	CONCERTO	construction of novel certification methods and means of compliance for disruptive technologies	[029]
30	Convert2Green	Converting facilities network for accelerating uptake of climate neutral materials in innovative products	[030]
31	COSMHYC XL	Combined hybrid solution	[031] [158]
32	DENOX	Innovative technologies of electrochemical suppression and electromagnetic decomposition for nox reduction in aeroengines	[032]
33	DYONCON	Dynamic ions under nano-confinement for porous membranes with ultrafast gas permeation control	[033]
34	EASIER	Sustainablility increase of lightweight, multifunctional and intelligent airframe and engine parts	[034]
35	EASVOLEE	Effects on air quality of semi-volatile engine emissions	[035]
36	e-CODUCT	Fast-response electrically heated catalytic reactor technology for CO2 reduction	[036]
37	E-CONTRAIL	Artificial Neural Networks for the Prediction of Contrails and Aviation Induced Cloudiness	[037] [160] [161]
38	Ecoplastomer	Breakthrough technology for plastic and rubber waste circular tpe	[038]
39	ELECTROCOFS	Molecular design of electrically conductive covalent organic frameworks as efficient electrodes for lithium-	[039]
40	ELOBIO	Electrolysis of biomass	[040]
41	EN.MOTION	Enersens motion to thin insulation	[041]
42	ENABLEH2	Enabling cryogenic hydrogen based co2 free air transport (enableh2)	[042]
43	ENHANCER	Engineering hybrid metal nitrides/carbon-atom wire novel materials for high-performance electrochemical	[043]
44	ENIGMA	Supervisor control for enhanced electrical energy management	[044]

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List of identified R&I projects & relevant technologies related to the Aviation climate impact (3/7)

Index	*Project*	*Description*	*Ref.*
45	EuroScienceGateway	Leveraging the european compute infrastructures for data-intensive research guided by fair principles	[045]
46	EV4EU	Electric vehicles management for carbon neutrality in europe	[046]
47	EVOLVE	Electric vehicles point location optimisation via vehicular communications	[047]
48	FASTER-H2	Fuselage, rear fuselage and empennage with cabin and cargo architecture solution validation and technologies for h2 integration	[048] [158]
49	fLHYing tank	Flight demonstration of a liquid hydrogen load-bearing tank in an unmanned cargo platform	[049] [158]
50	FlyATM4E	Flying Air Traffic Management for the benefit of environment and	[050] [162]
51	FREE4LIB	Feasible recovery of critical raw materials	[051]
52	FunGraB	Functionalized graphene based electrode material for lithium sulfur batteries	[052]
53	GENESIS	Gauging the environmental sustainability of electric aircraft systems	[053]
54	GLOWOPT	Global-Warming-Optimized Aircraft design	[054] [165]
55	Green Graphene	Acceleration of market deployment	[055]
56	GREENCAP	Graphene, mxene and ionic liquid-based sustainable supercapacitor	[056]
57	GYROMAGS	Green recycling route for sm-co permanent magnet swarf	[057]
58	H2ELIOS	Hydrogen lightweight & innovative tank for zero-emission aircraft	[058] [158]
59	H2ME	Hydrogen mobility eu 2	[059]
60	HAIRMATE	Hybrid ac seating manufacturing & testing	[060]
61	HARP	Next generation high density modular electrical interconnect solution.	[061]
62	HE-ART	Hybrid electric propulsion system for regional aircraft	[062] [158]
63	HEAVEN	High power density fc system for aerial passenger vehicle fueled by liquid hydrogen	[063] [158]
64	HECATE	Hybrid electric regional aircraft distribution technologies	[064] [158]
65	HERA	Hybrid-electric regional architecture	[065] [158]
66	HERFUSE	Hybrid-electric regional fuselage & empennages	[066] [158]

List of identified R&I projects & relevant technologies related to the Aviation climate impact (4/7)

Index	*Project*	*Description*	*Ref.*
67	HERWINGT	hybrid electric regional wing integration novel green technologies - herwingt	[067] [158]
68	HighSpin	High-voltage spinel lnmo silicon-graphite cells and modules for automotive and aeronautic transport applications	[068]
69	HIPECO2	Membrane electrode assembly for the high pressure electrochemical conversion of CO2 to C2H4	[069]
70	HIVOMOT	High power and voltage operation of electric motors in aeronautics	[070]
71	HYDEA	Hydrogen demonstrator for aviation	[071] [158]
72	HYDROGENATE	Hydrogen-based intrinsic-flame-instability-controlled clean and efficient combustion	[072]
73	HYNANOSTORE	Hybrid nanostructured systems for sustainable energy storage	[073]
74	HYPERION	Development of a Decision Support System for Improved Resilience & Sustainable Reconstruction of historic areas to cope with Climate Change	[074]
75	HyPoTraDe	Hydrogen fuel cell electric power train demonstration	[075] [158]
76	IDEN	Innovative distributed electrical network	[076]
77	IMITAES	Insulation monitoring for IT aerospace electrical systems	[077]
78	INDIGO	Integration and digital demonstration of low-emission aircraft technologies and airport operations	[078]
79	InnoBuyer	Learning, sharing and co-design in innovation procurement between innovation suppliers and buyers	[079]
80	INNOVA MEASURE V	Development of indicators & econometric analysis on r&i performance	[080]
81	IntelLiGent	Innovative and sustainable high voltage li-ion cells for next generation (ev) batteries	[081]
82	IRISS	International ecosystem for accelerating the transition to safe-and-sustainable-by-design materials, products and processes	[082]
83	JIVE	Hydrogen vehicles accroass eu	[083]
84	LEAFINNOX	Development of the lean azimuthal flame as an innovative aviation gas turbine low-nox combustion concept	[084]
85	LiBAT	Development of a high voltage lithium battery	[085]
86	LiquidS	Energy storage with bulk liquid redox materials	[086]
87	MacGhyver	Microfluidic wastewater treatment and creation of green hydrogen via electrochemical reactions	[087]
88	MAF	H2020-eu.3.4.5.4.,H2020-eu.3.4.	[088]

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Index	Project	List of identified R&I projects & relevant technologies related to the Aviation climate impact (5/7) Description	Ref.
89	MATISSE	Multifunctional structures with quasi-solid-state li-ion battery cells and sensors for the next generation climate neutral	[089]
90	MEXCAT	Metal exsolved catalysts for the co2 valorisation to methanol: design, synthesis, and characterisation of next-generation catalysts, unravelling their structure-activity relationship	[090]
91	MIMOSA	Multimaterial airframes based on 3D joints between am metals and carbon-fiber composites	[091]
92	MultiMag	Multi-functional, multi-material magnetic components and structures for electrification	[092]
93	MUSIC	Materials for sustainable sodium-ion capacitors	[093]
94	MYTHOS	Medium-range hybrid low-pollution flexi-fuel/hydrogen sustainable engine	[094]
95	NADIA	Novel air distribution approaches	[095]
96	NATFOX	Novel nano thin film oxygen electrodes for solid oxide cells	[096]
97	NEVERMORE	New enabling visions and tools for end-users and stakeholders thanks to a common modeling framework towards a climate	[097]
98	NEWBORN	Next generation high power fuel cells for airborne applications	[098] [158]
99	NIMPHEA	Next generation of improved high temperature membrane electrode assembly for aviation	[099]
100	NITRO-EARTH	Nitrogen chemistry with alkaline-earth metals	[100]
101	NOUVEAU	Novel electrode coatings and interconnect for sustainable and reusable soec	[101]
102	NoVOC	Eliminating voc from battery manufacturing through dry or wet processing	[102]
103	O2FREE	Metal-air battery integration for cargo compartment fire suppression	[103]
104	OFELIA	Open Fan for Environmental Low Impact of Aviation (sustainable aviation engines	[104]
105	OHPERA	Optimised halide perovskite nanocrystalline based electrolyser for clean, robust, efficient and decentralised production of h2	[105]
106	OPTHYCS	Optic fibre-based hydrogen leak control systems	[106]
107	OVERLEAF	Novel low-pressure cryogenic liquid hydrogen storage for aviation.	[107]
108	PERF-AI	Enhanced aircraft performance ..	[108]
109	PHIVE	Power electronics high voltage technologies	[109]
110	PHP2	Pulsating heat pipes for hybrid propulsion systems	[110]

Index	Project	List of identified R&I projects & relevant technologies related to the Aviation climate impact (6/7) Description	Ref.
111	PIONEER	Open innovation platform for optimising production systems by combining product development, virtual engineering workflows	[111]
112	PJ.01-W2 EAD PJ.01-W2-08A2	Automatic controlled time of arrival (CTA) for management of arrival in en-route and on the ground	[112]
113	PJ.02-W2 AART PJ.02-W2-21.6	Surface route planning and management operations	[113]
114	PJ.06-01	Optimised traffic management to enable free routing in high and very high complexity environment	[114]
115	PJ.07-W2-38	Enhanced integration of AU trajectory definition and network management processes	[115]
116	PJ.07-W2-40	Mission trajectories management with integrated DMAs Type 1 and Type 2	[116]
117	PJ.09-W2-44 #201	Dynamic airspace configuration (DAC)	[117]
118	PJ.10 W2 PROSA	Collaborative control	[118] [166]
119	PJ.18-W2-53A	Increased automation in planning and tactical separation management	[119]
120	PJ.18-W2-56	Air/Ground trajectory synchronisation via lateral and vertical complex CPDLC clearances to support TBO	[120]
121	PJ.18-W2-57	RBT revision supported by datalink and increased automation	[121]
122	PJ.38-01	ADS-C common service	[122]
123	POMZAB	High energy density and long cycle life near-neutral zn-air rechargeable batteries using polyoxometalates nanoclusters as homogenous catalysts	[123]
124	PSIONIC	High voltage, room temperature single-ion polymer electrolyte for safer all solid state lithium metal batteries	[124]
125	PULSELiON	Pulsed laser deposition technology for solid state battery manufacturing supported by digitalization	[125]
126	RAISE	Reliable aircraft electrical insulation system selection	[126]
127	RAPTOR	Research of Aviation PM Technologies, mOdelling and Regulation	[127] [167]
128	ROAD TRHYP	Road trailer design - use of type v thermoplastic tube with light composite structure for hydrogen transport	[128]
129	SEATBELT	Solid-state lithium metal battery with in situ hybrid electrolyte	[129]
130	SeNSE	Lithium-ion battery with silicon anode, nickel-rich cathode and in-cell sensor for electric vehicles	[130]
131	SIENA	Scalability investigation of hybrid electric concepts for next-generation aircraft	[131]
132	SiGNE	Composite silicon/graphite anodes with ni-rich cathodes and safe ether based electrolytes for high capacity li-ion batteries	[132]

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List of identified R&I projects & relevant technologies related to the Aviation climate impact (7/8)			
Index	*Project*	*Description*	*Ref.*
133	SiLiS	High capacity all-solid-state silicon-lithium-sulfide cells for energy storage applications	[133]
134	SJU Ref.: 10	Optimised route network using advanced RNP	[134]
135	SJU Ref.: 11	Continous descent operations (CDO) using point merge	[135]
136	SJU Ref.: 33	Free route through the use of free routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and within permanently low to medium complexity environments	[136]
137	SMART BATTERY	Increasing the efficiency, sustainability and lifecycles of battery systems through advanced module-level power electronics	[137]
138	SmartOptoelectronics	Machine-learning-guided design of perovskite lanthanum oxide cathodes for solid oxide fuel cells	[138]
139	SMR ACAP	SMR aircraft architecture and technology integration project	[139] [158]
140	SOLiD	Sustainable manufacturing and optimized materials and interfaces for lithium metal batteries with digital quality control	[140]
141	SOLIFLY	Semi-solid-state li-ion batteries functionally integrated in composite structures for next generation hybrid electric airliner	[141]
142	SPARE	Full scale innovative composite pax and cargo floor grids for regional aircraft fuselage barrel on - ground demonstrators.	[142]
143	SPARTAN	Smart multilevel power conditioning for aeronautical electrical units	[143]
144	STORMING	Structured unconventional reactors for CO2-free methane catalytic cracking	[144]
145	SUPERZINC	Sustainable powder materials for zinc rechargeable batteries	[145]
146	SWITCH	Sustainable water-injecting turbofan comprising hybrid-electrics	[146] [158]
147	TheMa4HERA	Thermal management for the hybrid electric regional aircraft	[147] [158]
148	THERMAC	Thermal-aware resource management for modern computing platform for next gen ac	[148]
149	THERMOBAT	Ferrosilicon latent heat thermophotovoltaic battery	[149]
150	TULIPS	Demonstrating lower polluting solutions for sustainable airports across europe	[150]
151	ULICBat	User behaviour informed learning and intelligent control for charging of vehicle battery packs	[151]
152	UNIFIER19	Community friendly miniliner	[152]
153	UNPRECEDENTED	Unrevealing the mechanisms involved when producing biodiesel from waste oil using a combined experimental and theoretical methodology	[153]
154	Up Wing	Ultra performance wing	[154] [158]

List of identified R&I projects & relevant technologies related to the Aviation climate impact (8/8)			
Index	*Project*	*Description*	*Ref.*
155	WATTsUP	Wattsup electric flight to future	[155]
156			
157			
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160			

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APPENDIX E: SCIENTIFIC APPLICATION AREAS & THEME TYPES

Table 4: Scientific application areas and attributed theme type

Science applications and themes related to the selected CLAIM relevant (Mainly based on Cordis website and SESAR website references)						
Scientific application areas and attributed theme type					*Scientific application areas*	
Ind	*Code*	*Science application description (*)*	*Code*	*Theme type*	*Theme group*	*Theme description*
1	[SA01]	Aeronautical engineering	S/D	Science/Discipline	Group "D"	Engineering activities
2	[SA02]	Air pollution engineering	S/D	Science/Discipline	Group "D"	Engineering activities
3	[SA03]	Air traffic management	S/D	Science/Discipline	Group "G"	Management activities
4	[SA04]	Sensors	Tech	Technology	Group "F"	Innovative technologies, materials and devices
5	[SA05]	SMR Open-Fan engine architecture	Arch	Architecture	Group "I"	Innovative Architectures
6	[SA06]	Aircraft	Tech	Technology	Group "A"	New air transport platforms or concepts
7	[SA07]	Airport engineering	S/D	Science/Discipline	Group "D"	Engineering activities
8	[SA08]	Renevable energy	S/D	Science/Discipline	Group "J"	Circularity in Aviation
9	[SA09]	Waste treatment processes	S/D	Science/Discipline	Group "J"	Circularity in Aviation
10	[SA10]	Big data	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
11	[SA11]	Biofuels	Tech	Technology	Group "E"	New energy power source with low emission
12	[SA12]	Biomass	Tech	Technology	Group "E"	New energy power source with low emission
13	[SA13]	MW Hybrid electric power train	Tech	Technology	Group "F"	Innovative technologies, materials and devices
14	[SA14]	Biosphera	S/D	Science/Discipline	Group "J"	Circularity in Aviation
15	[SA15]	Business models	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
16	[SA16]	Cabin noise supprection	Tech	Technology	Group "F"	Innovative technologies, materials and devices
17	[SA17]	Climatic changes	S/D	Science/Discipline	Group "C"	Environmental neutrality, emission and air quality
18	[SA18]	Automotive engineering	S/D	Science/Discipline	Group "D"	Engineering activities
19	[SA19]	Electric batteries	Tech	Technology	Group "F"	Innovative technologies, materials and devices
20	[SA20]	Alkali metals	Tech	Technology	Group "F"	Innovative technologies, materials and devices
21	[SA21]	Data processing	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
22	[SA22]	Machine learning	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
23	[SA23]	Databases	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
24	[SA24]	Thermal engine	Tech	Technology	Group "F"	Innovative technologies, materials and devices
25	[SA25]	Ecology	S/D	Science/Discipline	Group "J"	Circularity in Aviation
26	[SA26]	Ecosystems	S/D	Science/Discipline	Group "J"	Circularity in Aviation
27	[SA27]	Electric vehicles	Tech	Technology	Group "E"	New energy power source with low emission
28	[SA28]	Electrolysis	Tech	Technology	Group "E"	New energy power source with low emission
29	[SA29]	Emission reduction	S/D	Science/Discipline	Group "C"	Environmental neutrality, emission and air quality
30	[SA30]	Pollution	S/D	Science/Discipline	Group "C"	Environmental neutrality, emission and air quality
31	[SA31]	Freight transport	AS	Aviation sector	Group "B"	Involved scientific areas or disciplines
32	[SA32]	Hydrocarbons	Tech	Technology	Group "E"	New energy power source with low emission
33	[SA33]	Internet of Things	Tech	Technology	Group "K"	Transversal and synergic sectors
34	[SA34]	Liquid fuels	Tech	Technology	Group "E"	New energy power source with low emission
35	[SA35]	Innovation management	S/D	Science/Discipline	Group "G"	Management activities

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Science applications and themes related to the selected CLAIM relevant
(Mainly based on Cordis website and SESAR website references)

Scientific application areas and attributed theme type					Scientific application areas	
Ind	Code	Science application description (*)	Code	Theme type	Theme group	Theme description
36	[SA36]	Mathematical model	DT	Digital tooling	Group "K"	Transversal and synergic sectors
37	[SA37]	Meteorology	S/D	Science/Discipline	Group "C"	Environmental neutrality, emission and air quality
38	[SA38]	Planets	S/D	Science/Discipline	Group "E"	New energy power source with low emission
39	[SA39]	Production economics	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
40	[SA40]	Recycling	S/D	Science/Discipline	Group "J"	Circularity in Aviation
41	[SA41]	Drones	Tech	Technology	Group "A"	New air transport platforms or concepts
42	[SA42]	Statistics and probability	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
43	[SA43]	Sustainable economy	S/D	Science/Discipline	Group "J"	Circularity in Aviation
44	[SA44]	System learning	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
45	[SA45]	Transversal promotion	Trns	Transversal action	Group "K"	Transversal and synergic sectors
46	[SA46]	Autonomous vehicles	Tech	Technology	Group "A"	New air transport platforms or concepts
47	[SA47]	Public transport	Ser	Service	Group "B"	Involved scientific areas or disciplines
48	[SA48]	Smart sensors	Tech	Technology	Group "F"	Innovative technologies, materials and devices
49	[SA49]	Avionics cooling	Tech	Technology	Group "F"	Innovative technologies, materials and devices
50	[SA50]	Material engineering	S/D	Science/Discipline	Group "D"	Engineering activities
51	[SA51]	Aliphatic compounds	Tech	Technology	Group "F"	Innovative technologies, materials and devices
52	[SA52]	Inorganic compounds	Tech	Technology	Group "F"	Innovative technologies, materials and devices
53	[SA53]	Deep learning	Tech	Technology	Group "K"	Transversal and synergic sectors
54	[SA54]	Computational intelligence	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
55	[SA55]	Electric energy	Tech	Technology	Group "E"	New energy power source with low emission
56	[SA56]	Volatic organic compounds	Envi	Environmental impact	Group "C"	Environmental neutrality, emission and air quality
57	[SA57]	Transition metals	Tech	Technology	Group "F"	Innovative technologies, materials and devices
58	[SA58]	Alkaline earth metals	Tech	Technology	Group "F"	Innovative technologies, materials and devices
59	[SA59]	Electrocatalysis	Tech	Technology	Group "E"	New energy power source with low emission
60	[SA60]	Alcohols	Tech	Technology	Group "E"	New energy power source with low emission
61	[SA61]	Electric motor	Tech	Technology	Group "F"	Innovative technologies, materials and devices
62	[SA62]	Catalysis	Tech	Technology	Group "E"	New energy power source with low emission
63	[SA63]	Ozone depletion	Envi	Environmental impact	Group "C"	Environmental neutrality, emission and air quality
64	[SA64]	Productivity	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
65	[SA65]	Power engineering	Tech	Technology	Group "D"	Engineering activities
66	[SA66]	Thermochemistry	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
67	[SA67]	Sustainable Sodium-Ion Capacitors	Tech	Technology	Group "F"	Innovative technologies, materials and devices
68	[SA68]	Climatology	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
69	[SA69]	Artificial intelligence	S/D	Science/Discipline	Group "K"	Transversal and synergic sectors
70	[SA70]	Composites	Tech	Technology	Group "F"	Innovative technologies, materials and devices
71	[SA71]	Data science	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
72	[SA72]	Energy and Fuels	Tech	Technology	Group "B"	Involved scientific areas or disciplines
73	[SA73]	Software	Tech	Technology	Group "K"	Transversal and synergic sectors
74	[SA74]	Mining and mineral processing	Tech	Technology	Group "B"	Involved scientific areas or disciplines
75	[SA75]	Waste management	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
76	[SA76]	Coating and films	Tech	Technology	Group "F"	Innovative technologies, materials and devices
77	[SA77]	Electrochemistry	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
78	[SA78]	Atmospheric sciences	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
79	[SA79]	Environmental sciences	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
80	[SA80]	Electromagnetism and electronics	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
81	[SA81]	Economics	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
82	[SA82]	Governace	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
83	[SA83]	Polymer science	Tech	Technology	Group "B"	Involved scientific areas or disciplines
84	[SA84]	ADS-C	Opr	Operations	Group "F"	Innovative technologies, materials and devices

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Scientific application areas and attributed theme type					*Scientific application areas*	
Ind	*Code*	*Science application description (*)*	*Code*	*Theme type*	*Theme group*	*Theme description*
85	[SA85]	Cost efficiency	Opr	Operations	Group “B”	Involved scientific areas or disciplines
86	[SA86]	DAC	Opr	Operations	Group “A”	New air transport platforms or concepts
87	[SA87]	Enhanced safety	Opr	Operations	Group “B”	Involved scientific areas or disciplines
88	[SA88]	Improve predictability	Opr	Operations	Group “H	New operational solutions
89	[SA89]	Optimised capacity	Opr	Operations	Group “H	New operational solutions
90	[SA90]	Reduced fuel consumption and emissio	Opr	Operations	Group "C"	Environmental neutrality, emission and air quality
91	[SA91]	MTM	Opr	Operations	Group “H	New operational solutions
92	[SA92]	Trajectory definition	Opr	Operations	Group “H	New operational solutions
93	[SA93]	Network management	Opr	Operations	Group “G”	Management activities
94	[SA94]	Air-to-Ground trajectory synchronisatio	Opr	Operations	Group “H	New operational solutions
95	[SA95]	CPDLC clearances	Opr	Operations	Group “H	New operational solutions
96	[SA96]	Planning automation	Opr	Operations	Group “H	New operational solutions
97	[SA97]	Separation management	Opr	Operations	Group “H	New operational solutions
98	[SA98]	Collaborative control	Opr	Operations	Group “H	New operational solutions
99	[SA99]	Automatic CTA	Opr	Operations	Group “H	New operational solutions
100	[SA100]	Surface route planning	Opr	Operations	Group “H	New operational solutions
101	[SA101]	Operation management	S/D	Science/Discipline	Group “H	New operational solutions
102	[SA102]	OTM	Opr	Operations	Group “H	New operational solutions
103	[SA103]	Free routing for flight	Opr	Operations	Group “H	New operational solutions
104	[SA104]	CDO	Opr	Operations	Group “H	New operational solutions
105	[SA105]	Optimised Route network	Opr	Operations	Group “H	New operational solutions
106	[SA106]	Additive manufacturing	Tech	Technology	Group "F"	Innovative technologies, materials and devices
107	[SA107]	Control systems	Tech	Technology	Group "F"	Innovative technologies, materials and devices
108	[SA108]	Textiles	Tech	Technology	Group "F"	Innovative technologies, materials and devices
109	[SA109]	Hydrogen energy	Tech	Technology	Group “E”	New energy power source with low emission
110	[SA110]	Heat engineering	S/D	Science/Discipline	Group "D"	Engineering activities
111	[SA111]	Automation	Tech	Technology	Group "F"	Innovative technologies, materials and devices
112	[SA112]	Remote sensing	Tech	Technology	Group "F"	Innovative technologies, materials and devices
113	[SA113]	Electric power generation	Tech	Technology	Group “E”	New energy power source with low emission
114	[SA114]	Combined heat and power	Tech	Technology	Group “B”	Involved scientific areas or disciplines
115	[SA115]	Organometallic chemistry	S/D	Science/Discipline	Group “B”	Involved scientific areas or disciplines
116	[SA116]	Energy conversion	Tech	Technology	Group "F"	Innovative technologies, materials and devices
117	[SA117]	Fibers	Tech	Technology	Group "F"	Innovative technologies, materials and devices
118	[SA118]	Fuel cells	Tech	Technology	Group “E”	New energy power source with low emission
119	[SA119]	Graphene	Tech	Technology	Group "F"	Innovative technologies, materials and devices
120	[SA120]	Hybrid electric turboprop	Tech	Technology	Group "F"	Innovative technologies, materials and devices
121	[SA121]	Manufacturing engineering	S/D	Science/Discipline	Group “B”	Involved scientific areas or disciplines
122	[SA122]	Multi-sector cooperations	Trns	Transversal action	Group “K”	Transversal and synergic sectors
123	[SA123]	Nano-materials	Tech	Technology	Group "F"	Innovative technologies, materials and devices
124	[SA124]	Natural gas	Tech	Technology	Group “E”	New energy power source with low emission
125	[SA125]	Noise testing Rig	Demo	Demonstrator	Group "L"	Lab & Demonstrators
126	[SA126]	Regulatory Materials	RL	Rules	Group "M"	Regulation
127	[SA127]	SMR architecture	AA	Aircraft Architecture	Group “I”	Innovative Architectures
128	[SA128]	Thermodynamic engineering	S/D	Science/Discipline	Group “B”	Involved scientific areas or disciplines
129	[SA129]	Quality validation of aircraft	Mtd	Methodology	Group “B”	Involved scientific areas or disciplines
130	[SA130]	Carbon fibers	Tech	Technology	Group "F"	Innovative technologies, materials and devices
131	[SA131]	Compliance methodologies	Mtd	Methodology	Group “B”	Involved scientific areas or disciplines
132	[SA132]	Electric power distribution	Tech	Technology	Group “E”	New energy power source with low emission
133	[SA133]	Gear box & propeller	Tech	Technology	Group "F"	Innovative technologies, materials and devices
134	[SA134]	H2 combustion system	Tech	Technology	Group "F"	Innovative technologies, materials and devices

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Scientific application areas and attributed theme type					Scientific application areas	
Ind	*Code*	*Science application description (*)*	*Code*	*Theme type*	*Theme group*	*Theme description*
135	[SA135]	LH2 engine fuel system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
136	[SA136]	Engine integration and controls	Tech	Technology	Group "F"	Innovative technologies, materials and devices
137	[SA137]	Dual-fuel system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
138	[SA138]	H2 tank system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
139	[SA139]	Ultra-efficient airframe	Tech	Technology	Group "I"	Innovative Architectures
140	[SA140]	Hydrogen enabled integrated airframe	Tech	Technology	Group "I"	Innovative Architectures
141	[SA141]	Composite vacuum insulated tank	Tech	Technology	Group "F"	Innovative technologies, materials and devices
142	[SA142]	LH2 re-fuelling and supply system	Tech	Technology	Group "E"	New energy power source with low emission
143	[SA143]	Tank pressure control system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
144	[SA144]	Composite foam insulated tank	Tech	Technology	Group "F"	Innovative technologies, materials and devices
145	[SA145]	SHM/H2 sensors	Tech	Technology	Group "F"	Innovative technologies, materials and devices
146	[SA146]	LH2 refuelling system	Tech	Technology	Group "E"	New energy power source with low emission
147	[SA147]	Optimized power management	Tech	Technology	Group "G"	Management activities
148	[SA148]	SMR Ultra-Fan	Tech	Technology	Group "F"	Innovative technologies, materials and devices
149	[SA149]	Integarted high voltage electrical distril	Tech	Technology	Group "I"	Innovative Architectures
150	[SA150]	Primary power distribution	Tech	Technology	Group "I"	Innovative Architectures
151	[SA151]	Secondary power diostribution	Tech	Technology	Group "I"	Innovative Architectures
152	[SA152]	Power conversion	Tech	Technology	Group "F"	Innovative technologies, materials and devices
153	[SA153]	Control	Tech	Technology	Group "F"	Innovative technologies, materials and devices
154	[SA154]	Cables/Connectors	Tech	Technology	Group "F"	Innovative technologies, materials and devices
155	[SA155]	HERA concept (Twin engine)	Cnpc	Concept	Group "A"	New air transport platforms or concepts
156	[SA156]	HERA concept (Distribuited propulsion)	Cnpc	Concept	Group "A"	New air transport platforms or concepts
157	[SA157]	Innovative wing architecture	Arch	Architecture	Group "I"	Innovative Architectures
158	[SA158]	Advanced composite material structure	Tech	Technology	Group "F"	Innovative technologies, materials and devices
159	[SA159]	H/E propulsion and system integration	Tech	Technology	Group "F"	Innovative technologies, materials and devices
160	[SA160]	Engine fuel system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
161	[SA161]	H2 burn (low Nox)	Tech	Technology	Group "F"	Innovative technologies, materials and devices
162	[SA162]	Aircraft integration	Tech	Technology	Group "F"	Innovative technologies, materials and devices
163	[SA163]	Fuel cell powertrain control	Tech	Technology	Group "F"	Innovative technologies, materials and devices
164	[SA164]	DC-DC converter	Tech	Technology	Group "F"	Innovative technologies, materials and devices
165	[SA165]	High voltage battery pack	Tech	Technology	Group "F"	Innovative technologies, materials and devices
166	[SA166]	Cryo enabled thermal management sys	Tech	Technology	Group "F"	Innovative technologies, materials and devices
167	[SA167]	Distribuited propulsion system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
168	[SA168]	Fuel cell power source	Tech	Technology	Group "E"	New energy power source with low emission
169	[SA169]	High voltage battery system	Tech	Technology	Group "E"	New energy power source with low emission
170	[SA170]	Electric propulsion system	Tech	Technology	Group "E"	New energy power source with low emission
171	[SA171]	LH2 storage	Tech	Technology	Group "E"	New energy power source with low emission
172	[SA172]	Hydrogen propelled concept	Cnpc	Concept	Group "A"	New air transport platforms or concepts
173	[SA173]	SAF propelled concept	Cnpc	Concept	Group "A"	New air transport platforms or concepts
174	[SA174]	Ultra performance wing	Tech	Technology	Group "A"	New air transport platforms or concepts
175	[SA175]	Integrated HAR SAF Wing	Cnpc	Concept	Group "A"	New air transport platforms or concepts
176	[SA176]	Hybrid water-enhanced turbofan	Tech	Technology	Group "F"	Innovative technologies, materials and devices
177	[SA177]	Reduced life-cycle GHG emissions	Tech	Technology	Group "C"	Environmental neutrality, emission and air quality
178	[SA178]	AEro1	Demo	Demonstrator	Group "L"	Lab & Demonstrators
179	[SA179]	Innovative fuselage and emopennages	Tech	Technology	Group "I"	Innovative Architectures
180	[SA180]	H/E energy storage and system integrat	Tech	Technology	Group "F"	Innovative technologies, materials and devices
181	[SA181]	Thermal management system	Tech	Technology	Group "F"	Innovative technologies, materials and devices
182	[SA182]	Cabin air supply	Tech	Technology	Group "F"	Innovative technologies, materials and devices
183	[SA183]	Conditioning	Tech	Technology	Group "F"	Innovative technologies, materials and devices
184	[SA184]	Distribution Hybrid electric system cool	Tech	Technology	Group "F"	Innovative technologies, materials and devices
185	[SA185]	SAF - SMR concept	Cnpc	Concept	Group "A"	New air transport platforms or concepts
186	[SA186]	LH2 - SMR concept	Cnpc	Concept	Group "A"	New air transport platforms or concepts
187	[SA187]	Computational science	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines
188	[SA188]	Simulation software	S/D	Science/Discipline	Group "B"	Involved scientific areas or disciplines

Table 5: Connection scientific application areas vs themes of roadmaps

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Connection Scientific Application Areas vs Themes of Roadmaps

Index	Themes of Roadmap	Technologies	Operations	Alternative Fuels	Market based measures	Others (Added)	Theme description
1	Group "D"					Yes	Engineering activities
2	Group "D"					Yes	Engineering activities
3	Group "G"				Yes		Management activities
4	Group "F"	Yes					Innovative technologies, materials and devices
5	Group "I"					Yes	Innovative Architectures
6	Group "A"	Yes				Yes	New air transport platforms or concepts
7	Group "D"					Yes	Engineering activities
8	Group "J"			Yes			Circularity in Aviation
9	Group "J"	Yes		Yes			Circularity in Aviation
10	Group "K"					Yes	Transversal and synergic sectors
11	Group "E"			Yes			New energy power source with low emission
12	Group "E"			Yes			New energy power source with low emission
13	Group "F"	Yes					Innovative technologies, materials and devices
14	Group "J"					Yes	Circularity in Aviation
15	Group "K"				Yes		Transversal and synergic sectors
16	Group "F"	Yes					Innovative technologies, materials and devices
17	Group "C"					Yes	Environmental neutrality, emission and air quality
18	Group "D"					Yes	Engineering activities
19	Group "F"	Yes					Innovative technologies, materials and devices
20	Group "F"	Yes					Innovative technologies, materials and devices
21	Group "K"					Yes	Transversal and synergic sectors
22	Group "K"					Yes	Transversal and synergic sectors
23	Group "K"					Yes	Transversal and synergic sectors
24	Group "F"	Yes					Innovative technologies, materials and devices
25	Group "J"					Yes	Circularity in Aviation
26	Group "J"					Yes	Circularity in Aviation
27	Group "E"			Yes			New energy power source with low emission
28	Group "E"			Yes			New energy power source with low emission
29	Group "C"					Yes	Environmental neutrality, emission and air quality
30	Group "C"					Yes	Environmental neutrality, emission and air quality
31	Group "B"					Yes	Involved scientific areas or disciplines
32	Group "E"			Yes			New energy power source with low emission
33	Group "K"	Yes					Transversal and synergic sectors
34	Group "E"			Yes			New energy power source with low emission
35	Group "G"				Yes		Management activities
36	Group "K"					Yes	Transversal and synergic sectors
37	Group "C"					Yes	Environmental neutrality, emission and air quality
38	Group "E"			Yes			New energy power source with low emission
39	Group "B"				Yes		Involved scientific areas or disciplines
40	Group "J"					Yes	Circularity in Aviation
41	Group "A"	Yes					New air transport platforms or concepts
42	Group "B"				Yes		Involved scientific areas or disciplines
43	Group "J"				Yes		Circularity in Aviation
44	Group "K"					Yes	Transversal and synergic sectors
45	Group "K"					Yes	Transversal and synergic sectors
46	Group "A"	Yes					New air transport platforms or concepts
47	Group "B"					Yes	Involved scientific areas or disciplines
48	Group "F"	Yes					Innovative technologies, materials and devices
49	Group "F"	Yes					Innovative technologies, materials and devices
50	Group "D"					Yes	Engineering activities

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Connection Scientific Application Areas vs Themes of Roadmaps							
Index	Themes of Roadmap	Technologies	Operations	Alternative Fuels	Market based measures	Others (Added)	Theme description
51	Group "F"	Yes					Innovative technologies, materials and devices
52	Group "F"	Yes					Innovative technologies, materials and devices
53	Group “K”	Yes				Yes	Transversal and synergic sectors
54	Group “K”					Yes	Transversal and synergic sectors
55	Group “E”			Yes			New energy power source with low emission
56	Group "C"					Yes	Environmental neutrality, emission and air quality
57	Group "F"	Yes					Innovative technologies, materials and devices
58	Group "F"	Yes					Innovative technologies, materials and devices
59	Group “E”			Yes			New energy power source with low emission
60	Group “E”			Yes			New energy power source with low emission
61	Group "F"	Yes					Innovative technologies, materials and devices
62	Group “E”			Yes			New energy power source with low emission
63	Group "C"					Yes	Environmental neutrality, emission and air quality
64	Group “B”				Yes		Involved scientific areas or disciplines
65	Group "D"					Yes	Engineering activities
66	Group “B”			Yes		Yes	Involved scientific areas or disciplines
67	Group "F"	Yes					Innovative technologies, materials and devices
68	Group “B”					Yes	Involved scientific areas or disciplines
69	Group “K”					Yes	Transversal and synergic sectors
70	Group "F"	Yes					Innovative technologies, materials and devices
71	Group “B”					Yes	Involved scientific areas or disciplines
72	Group “B”			Yes			Involved scientific areas or disciplines
73	Group “K”					Yes	Transversal and synergic sectors
74	Group “B”	Yes					Involved scientific areas or disciplines
75	Group “B”				Yes		Involved scientific areas or disciplines
76	Group "F"	Yes					Innovative technologies, materials and devices
77	Group “B”			Yes			Involved scientific areas or disciplines
78	Group “B”					Yes	Involved scientific areas or disciplines
79	Group “B”					Yes	Involved scientific areas or disciplines
80	Group “B”	Yes					Involved scientific areas or disciplines
81	Group “B”				Yes		Involved scientific areas or disciplines
82	Group “B”				Yes		Involved scientific areas or disciplines
83	Group “B”					Yes	Involved scientific areas or disciplines
84	Group "F"	Yes	Yes				Innovative technologies, materials and devices
85	Group “B”		Yes				Involved scientific areas or disciplines
86	Group “A”		Yes				New air transport platforms or concepts
87	Group “B”		Yes				Involved scientific areas or disciplines
88	Group “H		Yes				New operational solutions
89	Group “H		Yes				New operational solutions
90	Group "C"		Yes				Environmental neutrality, emission and air quality
91	Group “H		Yes				New operational solutions
92	Group “H		Yes				New operational solutions
93	Group “G”		Yes		Yes		Management activities
94	Group “H		Yes				New operational solutions
95	Group “H		Yes				New operational solutions
96	Group “H		Yes				New operational solutions
97	Group “H		Yes				New operational solutions
98	Group “H		Yes				New operational solutions
99	Group “H		Yes				New operational solutions
100	Group “H		Yes				New operational solutions

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Index	Themes of Roadmap	Connection Scientific Application Areas vs Themes of Roadmaps Technologies	Operations	Alternative Fuels	Market based measures	Others (Added)	Theme description
101	Group “H		Yes				New operational solutions
102	Group “H		Yes				New operational solutions
103	Group “H		Yes				New operational solutions
104	Group “H		Yes				New operational solutions
105	Group “H		Yes				New operational solutions
106	Group "F"	Yes					Innovative technologies, materials and devices
107	Group "F"	Yes					Innovative technologies, materials and devices
108	Group "F"	Yes					Innovative technologies, materials and devices
109	Group “E”			Yes			New energy power source with low emission
110	Group "D"			Yes			Engineering activities
111	Group "F"	Yes					Innovative technologies, materials and devices
112	Group "F"	Yes					Innovative technologies, materials and devices
113	Group “E”			Yes			New energy power source with low emission
114	Group “B”			Yes			Involved scientific areas or disciplines
115	Group “B”					Yes	Involved scientific areas or disciplines
116	Group "F"	Yes					Innovative technologies, materials and devices
117	Group "F"	Yes					Innovative technologies, materials and devices
118	Group “E”			Yes			New energy power source with low emission
119	Group "F"	Yes					Innovative technologies, materials and devices
120	Group "F"	Yes					Innovative technologies, materials and devices
121	Group “B”					Yes	Involved scientific areas or disciplines
122	Group “K”					Yes	Transversal and synergic sectors
123	Group "F"	Yes					Innovative technologies, materials and devices
124	Group “E”			Yes			New energy power source with low emission
125	Group "L"					Yes	Lab & Demonstrators
126	Group "M"					Yes	Regulation
127	Group “I”					Yes	Innovative Architectures
128	Group “B”					Yes	Involved scientific areas or disciplines
129	Group “B”					Yes	Involved scientific areas or disciplines
130	Group "F"	Yes					Innovative technologies, materials and devices
131	Group “B”					Yes	Involved scientific areas or disciplines
132	Group “E”			Yes			New energy power source with low emission
133	Group "F"	Yes					Innovative technologies, materials and devices
134	Group "F"	Yes					Innovative technologies, materials and devices
135	Group "F"	Yes					Innovative technologies, materials and devices
136	Group "F"	Yes					Innovative technologies, materials and devices
137	Group "F"	Yes					Innovative technologies, materials and devices
138	Group "F"	Yes					Innovative technologies, materials and devices
139	Group “I”	Yes					Innovative Architectures
140	Group “I”	Yes					Innovative Architectures
141	Group "F"	Yes					Innovative technologies, materials and devices
142	Group “E”			Yes			New energy power source with low emission
143	Group "F"	Yes					Innovative technologies, materials and devices
144	Group "F"	Yes					Innovative technologies, materials and devices
145	Group "F"	Yes					Innovative technologies, materials and devices
146	Group “E”			Yes			New energy power source with low emission
147	Group “G”			Yes			Management activities
148	Group "F"	Yes					Innovative technologies, materials and devices
149	Group “I”	Yes					Innovative Architectures
150	Group “I”	Yes					Innovative Architectures

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Connection Scientific Application Areas vs Themes of Roadmaps

Index	Themes of Roadmap	Technologies	Operations	Alternative Fuels	Market based measures	Others (Added)	Theme description
151	Group “I”	Yes					Innovative Architectures
152	Group "F"	Yes					Innovative technologies, materials and devices
153	Group "F"	Yes					Innovative technologies, materials and devices
154	Group "F"	Yes					Innovative technologies, materials and devices
155	Group “A”					Yes	New air transport platforms or concepts
156	Group “A”					Yes	New air transport platforms or concepts
157	Group “I”					Yes	Innovative Architectures
158	Group "F"	Yes					Innovative technologies, materials and devices
159	Group "F"	Yes					Innovative technologies, materials and devices
160	Group "F"	Yes					Innovative technologies, materials and devices
161	Group "F"	Yes					Innovative technologies, materials and devices
162	Group "F"	Yes					Innovative technologies, materials and devices
163	Group "F"	Yes					Innovative technologies, materials and devices
164	Group "F"	Yes					Innovative technologies, materials and devices
165	Group "F"	Yes					Innovative technologies, materials and devices
166	Group "F"	Yes					Innovative technologies, materials and devices
167	Group "F"	Yes					Innovative technologies, materials and devices
168	Group “E”			Yes			New energy power source with low emission
169	Group “E”			Yes			New energy power source with low emission
170	Group “E”			Yes			New energy power source with low emission
171	Group “E”			Yes			New energy power source with low emission
172	Group “A”					Yes	New air transport platforms or concepts
173	Group “A”					Yes	New air transport platforms or concepts
174	Group “A”	Yes					New air transport platforms or concepts
175	Group “A”					Yes	New air transport platforms or concepts
176	Group "F"	Yes					Innovative technologies, materials and devices
177	Group "C"					Yes	Environmental neutrality, emission and air quality
178	Group "L"					Yes	Lab & Demonstrators
179	Group “I”	Yes					Innovative Architectures
180	Group "F"	Yes					Innovative technologies, materials and devices
181	Group "F"	Yes					Innovative technologies, materials and devices
182	Group "F"	Yes					Innovative technologies, materials and devices
183	Group "F"	Yes					Innovative technologies, materials and devices
184	Group "F"	Yes					Innovative technologies, materials and devices
185	Group “A”					Yes	New air transport platforms or concepts
186	Group “A”					Yes	New air transport platforms or concepts
187	Group “B”						Involved scientific areas or disciplines
188	Group “B”						Involved scientific areas or disciplines

Table 6: Technologies, concepts and scientific areas vs CLAIM main topics

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Technologies, concepts and scientific areas vs CLAIM main topics (1/9)						
		CLAIM Main topics				
Index	Project	HE	H2Av	MorE	Technology, concept and/or science area	Ref.
1	3beLiEVe	Yes	-	Yes	[SA123] Manufacturing engineering [SA130] Thermodynamic engineering [SA03] Air traffic management	[001]
2	ACACIA	-	-	-	[SA41] Drones	[002] [156]
3	ADVAGEN	Yes	-	-	[SA19] Electric batteries	[003]
4	aEro	-	-	Yes	[SA30] Pollution [SA73] Energy and Fuels [SA06] Aircraft [SA183] AEro1	[004]
5	AM2SoftMag	Yes	-	-	[SA50] Material engineering [SA107] Additive manufacturing [SA43] Sustainable economy	[005]
6	AMBER	Yes	-	-	[SA06] Aircraft [SA17] Climatic changes [SA119] Fuel cells [SA61] Electric motor [SA137] Gear box & propeller [SA13] MW Hybrid electric power train [SA24] Thermal engine	[006] [157]
7	AMU-LED	Yes	-	Yes	[SA31] Freight transport [SA69] Artificial intelligence [SA35] Innovation management [SA21] Data processing [SA36] Mathematical model [SA124] Multi-sector cooperations	[007]
8	ASTRABAT	-	-	Yes	[SA51] Aliphatic compounds	[008]
9	ATRA	Yes	-	Yes	[SA06] Aircraft [SA03] Air traffic management	[009]
10	AUTO-MEA	Yes	-	-	[SA123] Manufacturing engineering [SA33] Internet of Things	[010]
11	BAE	-	-	-	[SA17] Climatic changes [SA02] Air pollution engineering [SA25] Ecology	[011]
12	BATNMR	Yes	-	Yes	[SA19] Electric batteries [SA08] Renevable energy [SA119] Fuel cells [SA20] Alkali metals	[012]
13	BatWoMan	Yes	-	Yes	[SA19] Electric batteries [SA43] Sustainable economy	[013]
14	BeCoM	Yes	-	-	[SA17] Climatic changes [SA69] Artificial intelligence [SA51] Aliphatic compounds [SA22] Machine learning [SA03] Air traffic management	[014]
15	CarbonNeutralLNG	Yes	-	Yes	[SA12] Biomass	[015]
16	CAVENDISH	-	Yes	-	[SA73] Energy and Fuels [SA43] Sustainable economy [SA01] Aeronautical engineering [SA06] Aircraft [SA138] H2 combustion system [SA139] LH2 engine fuel system [SA140] Engine integration and controls [SA141] Dual-fuel system [SA142] H2 tank system	[016]
17	CERISE	-	-	-	[SA17] Climatic changes [SA14] Biosphera	[017]
18	CETP	Yes	-	-	[SA08] Renevable energy	[018]

Technologies, concepts and scientific areas vs CLAIM main topics (2/9)						
		CLAIM Main topics				
Index	Project	HE	H2Av	MorE	Technology, concept and/or science area	Ref.
19	CHYLA	Yes	-	-	[SA55] Electric energy [SA06] Aircraft [SA82] Economics [SA126] Natural gas [SA119] Fuel cells	[019] [158]
20	CircoMod	-	-	-	[SA73] Energy and Fuels [SA43] Sustainable economy [SA17] Climatic changes [SA25] Ecology	[020]
21	CIRCULAIR	Yes	Yes	Yes	[SA11] Biofuels [SA15] Business models [SA66] Thermochemistry	[021]
22	CIRRUS-HL	-	-	-	[A19] Climatic changes	[022]
23	CLAIM	Yes	Yes	Yes	[SA06] Aircraft [SA68] Climatology [SA01] Aeronautical engineering	[023]
24	CLAIRPORT	-	-	-	[SA06] Aircraft [SA02] Air pollution engineering [SA07] Airport engineering	[024]
25	Clean(S)tack	Yes	-	Yes	[SA19] Electric batteries [SA55] Electric energy	[025]
26	Climaviation	-	-	-	[A19] Climatic changes	[026]
27	CLIMOP	-	-	-	[A7] Aircraft, [A19] Climatic changes, [A58] Pollution	[027]
28	COBRA	-	-	Yes	[SA19] Electric batteries [SA48] Smart sensors	[028]
29	CONCERTO	Yes	Yes	Yes	[SA29] Emission reduction [SA16] Cabin noise supprection [SA127] Noise testing Rig [SA128] Regulatory Materials [SA134] Compliance methodologies	[029]
30	Convert2Green	-	-	-	[SA46] Autonomous vehicles [SA08] Renevable energy [SA118] Fibers [SA109] Textiles	[030]
31	COSMHYC XL	Yes	Yes	-	[SA75] Mining and mineral processing [SA73] Energy and Fuels	[031] [158]
32	DENOX	-	-	-	[SA06] Aircraft [SA120] Aeronautical engineering [SA21] Data processing	[032]
33	DYONCON	-	Yes	-	[SA03] Air traffic management [SA125] Nano-materials	[033]
34	EASIER	-	-	Yes	[SA06] Aircraft [SA19] Electric batteries [SA111] Heat engineering	[034]
35	EASVOLEE	-	-	-	[SA02] Air pollution engineering [SA125] Nano-materials	[035]
36	e-CODUCT	Yes	-	-	[SA08] Renevable energy [SA60] Alcohols	[036]

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Technologies, concepts and scientific areas vs CLAIM main topics (3/9)

Index	Project	CLAIM Main HE	H2Av	MorE	Technology, concept and/or science area	Ref.
37	E-CONTRAIL	-	-	-	[SA17] Climatic changes [SA113] Remote sensing [SA53] Deep learning [SA54] Computational intelligence	[037] [160] [161]
38	Ecoplastomer	-	Yes	-	[SA84] Polymer science [SA40] Recycling	[038]
39	ELECTROCOFS	Yes	-	-	[SA19] Electric batteries [SA81] Electromagnetism and electronics [SA20] Alkali metals [SA52] Inorganic compounds	[039]
40	ELOBIO	-	Yes	-	[SA51] Aliphatic compounds [SA51] Aliphatic compounds [SA12] Biomass	[040]
41	EN.MOTION	Yes	Yes	Yes	[SA123] Manufacturing engineering [SA77] Coating and films	[041]
42	ENABLEH2	-	Yes	-	[SA06] Aircraft [SA73] Energy and Fuels	[042]
43	ENHANCER	Yes	-	-	[SA19] Electric batteries [SA125] Nano-materials [SA08] Renewable energy [SA20] Alkali metals	[043]
44	ENIGMA	Yes	-	-	[SA06] Aircraft [SA55] Electric energy	[044]
45	…roScienceGatew…	-	-	-	[SA21] Data processing [SA26] Ecosystems	[045]
46	EV4EU	-	-	Yes	[SA27] Electric vehicles [SA15] Business models	[046]
47	EVOLVE	Yes	-	Yes	[SA22] Machine learning [SA10] Big data [SA27] Electric vehicles [SA44] System learning	[047]
48	FASTER-H2	-	Yes	-	[SA119] Fuel cells [SA06] Aircraft [SA143] Ultra-efficient airframe [SA144] Hydrogen enabled integrated airframe	[048] [158]
49	fLHYing tank	-	Yes	-	[SA70] Material engineering [SA01] Aeronautical engineering [SA145] Composite vacuum insulated tank [SA146] LH2 re-fuelling and supply system [SA147] Tank pressure control system	[049] [158]
50	FlyATM4E	-	-	-	[SA06] Aircraft [SA03] Air traffic management [SA79] Atmospheric sciences	[050] [162] [163] [164]
51	FREE4LIB	Yes	-	Yes	[SA19] Electric batteries [SA40] Recycling	[051]
52	FunGraB	Yes	-	-	[T125] Manufacturing engineering [T108] Graphene [A25] Alkali metals	[052]
53	GENESIS	Yes	-	-	[SA120] Aeronautical engineering [SA06] Aircraft [SA32] Hydrocarbons [SA119] Fuel cells	[053]
54	GLOWOPT	-	-	-	[SA06] Aircraft [SA72] Data science	[054] [165]

Technologies, concepts and scientific areas vs CLAIM main topics (4/9)

Index	Project	CLAIM Main topics HE	H2Av	MorE	Technology, concept and/or science area	Ref.
55	Green Graphene	Yes	-	Yes	[SA121] Graphene [SA15] Business models [SA12] Biomass	[055]
56	GREENCAP	Yes	-	-	[S24] Electrochemistry [T122] Thermodynamic engineering [T108] Graphene [A77] Sustainable economy	[056]
57	GYROMAGS	-	-	Yes	[SA40] Recycling [SA08] Renevable energy [SA27] Electric vehicles [SA43] Sustainable economy	[057]
58	H2ELIOS	-	Yes	-	[SA123] Manufacturing engineering [SA06] Aircraft [SA07] Airport engineering [SA43] Sustainable economy [SA147] Tank pressure control system [SA148] Composite foam insulated tank [SA150] SHM/H2 sensors [SA151] LH2 refuelling system	[058] [158]
59	H2ME	-	Yes	-	[SA119] Fuel cells [SA27] Electric vehicles	[059]
60	HAIRMATE	Yes	-	-	[SA70] Material engineering [SA06] Aircraft	[060]
61	HARP	Yes	-	-	[SA17] Climatic changes	[061]
62	HE-ART	Yes	-	-	[SA122] Hybrid electric turboprop [SA06] Aircraft [SA152] Optimized power management [SA61] Electric motor [SA137] Gear box & propeller [SA13] MW Hybrid electric power train [SA24] Thermal engine	[062] [158]
63	HEAVEN	-	Yes	-	[SA01] Aeronautical engineering [SA119] Fuel cells [SA06] Aircraft [SA153] SMR Ultra-Fan	[063] [158]
64	HECATE	Yes	-	-	[SA06] Aircraft [SA73] Energy and Fuels [SA43] Sustainable economy [SA155] Primary power distribution [SA156] Secondary power diostribution [SA157] Power conversion [SA158] Control [SA159] Cables/Connectors	[064] [158]
65	HERA	Yes	-	-	[SA119] Fuel cells [SA06] Aircraft [SA160] HERA concept (Twin engine) [SA161] HERA concept (Distribuited propulsion)	[065] [158]
66	HERFUSE	Yes	-	-	[SA06] Aircraft [SA119] Fuel cells [SA163] Advanced composite material structures [SA184] Innovative fuselage and emopennages [SA186] H/E energy storage and system integration	[066] [158]
67	HERWINGT	Yes	-	-	[SA119] Fuel cells [SA73] Energy and Fuels [SA06] Aircraft [SA162] Innovative wing architecture [SA163] Advanced composite material structures [SA164] H/E propulsion and system integration	[067] [158]
68	HighSpin	Yes	-	Yes	[SA19] Electric batteries [SA01] Aeronautical engineering [SA18] Automotive engineering	[068]
69	HIPECO2	-	Yes	Yes	[SA78] Electrochemistry [SA59] Electrocatalysis [SA51] Aliphatic compounds [SA73] Energy and Fuels	[069]
70	HIVOMOT	Yes	-	Yes	[SA111] Heat engineering [SA06] Aircraft [SA32] Hydrocarbons [SA120] Aeronautical engineering	[070]
71	HYDEA	-	Yes	-	[SA43] Sustainable economy [SA110] Hydrogen energy [SA06] Aircraft [SA138] H2 combustion system [SA165] Engine fuel system [SA140] Engine integration and controls [SA166] H2 burn (low Nox) [SA167] Aircraft integration	[071] [158]
72	HYDROGENATE	-	Yes	Yes	[SA117] Energy conversion	[072]

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Technologies, concepts and scientific areas vs CLAIM main topics (5/9)

Index	Project	CLAIM Main topics: HE	H2Av	MorE	Technology, concept and/or science area	Ref.
73	HYNANOSTORE	Yes	-	-	[SA19] Electric batteries [SA08] Renewable energy [SA27] Electric vehicles [SA20] Alkali metals	[073]
74	HYPERION	-	-	-	[A19] Climatic changes, [A65] Sensors	[074]
75	HyPoTraDe	-	Yes	-	[SA119] Fuel cells [SA55] Electric energy [SA06] Aircraft [SA138] H2 combustion system [SA165] Engine fuel system [SA140] Engine integration and controls [SA166] H2 burn (low Nox) [SA167] Aircraft integration	[075] [158]
76	IDEN	Yes	Yes	Yes	[SA06] Aircraft [SA33] Internet of Things	[076]
77	IMITAES	Yes	-	Yes	[SA108] Control systems [SA136] Electric power distribution [SA114] Electric power generation	[077]
78	INDIGO	Yes	Yes	Yes	[SA06] Aircraft [SA02] Air pollution engineering [SA73] Energy and Fuels [SA07] Airport engineering	[078]
79	InnoBuyer	-	-	-	[SA35] Innovation management	[079]
80	INNOVA MEASURE V	-	-	-	[SA38] Planets [SA17] Climatic changes [SA45] Transversal promotion	[080]
81	IntelLiGent	Yes	-	-	[SA19] Electric batteries [SA43] Sustainable economy	[081]
82	IRISS	Yes	Yes	Yes	[SA83] Governace [SA26] Ecosystems [SA43] Sustainable economy	[082]
83	JIVE	-	Yes	-	[SA119] Fuel cells [SA47] Public transport [SA80] Environmental sciences	[083]
84	LEAFINNOX	-	-	-	[SA34] Liquid fuels [SA28] Electrolysis [SA32] Hydrocarbons [SA126] Natural gas [SA125] Nano-materials	[084]
85	LiBAT	Yes	-	-	[SA19] Electric batteries [SA06] Aircraft [SA120] Aeronautical engineering [SA20] Alkali metals	[085]
86	LiquidS	Yes	-	-	[SA19] Electric batteries [SA57] Transition metals [SA20] Alkali metals	[086]
87	MacGhyver	-	Yes	Yes	[SA78] Electrochemistry [SA43] Sustainable economy [SA09] Waste treatment processes	[087]
88	MAF	Yes	Yes	Yes	[SA132] Quality validation of aircraft [SA06] Aircraft [SA108] Control systems	[088]
89	MATISSE	Yes	-	Yes	[SA06] Aircraft [SA19] Electric batteries [SA135] Composites [SA03] Air traffic management	[089]
90	MEXCAT	Yes	Yes	Yes	[SA40] Recycling [SA08] Renewable energy [SA62] Catalysis	[090]

Technologies, concepts and scientific areas vs CLAIM main topics (6/9)

Index	Project	CLAIM Main: HE	H2Av	MorE	Technology, concept and/or science area	Ref.
91	MIMOSA	-	-	Yes	[SA118] Fibers [SA06] Aircraft [SA133] Carbon fibers [SA107] Additive manufacturing	[091]
92	MultiMag	Yes	-	-	[SA40] Recycling [SA107] Additive manufacturing	[092]
93	MUSIC	Yes	-	-	[SA67] Sustainable Sodium-Ion Capacitors	[093]
94	MYTHOS	Yes	Yes	-	[SA06] Aircraft [SA02] Air pollution engineering [SA73] Energy and Fuels [SA30] Pollution [SA22] Machine learning	[094]
95	NADIA	-	-	-	[SA74] Software [SA108] Control systems [SA130] Thermodynamic engineering [SA06] Aircraft	[095]
96	NATFOX	Yes	-	Yes	[SA117] Energy conversion [SA119] Fuel cells	[096]
97	NEVERMORE	Yes	-	Yes	[SA17] Climatic changes	[097]
98	NEWBORN	-	Yes	-	[SA119] Fuel cells [SA117] Energy conversion [SA06] Aircraft [SA173] Fuel cell power source [SA174] High voltage battery system [SA175] Electric propulsion system [SA176] LH2 storage	[098] [158]
99	NIMPHEA	Yes	-	Yes	[SA06] Aircraft [SA119] Fuel cells	[099]
100	NITRO-EARTH	Yes	-	-	[SA62] Catalysis [SA116] Organometallic chemistry	[100]
101	NOUVEAU	Yes	-	-	[SA76] Waste management [SA119] Fuel cells [SA22] Machine learning	[101]
102	NoVOC	Yes	-	-	[SA19] Electric batteries [SA27] Electric vehicles [SA77] Coating and films [SA56] Volatic organic compounds	[102]
103	O2FREE	Yes	-	-	[SA19] Electric batteries [SA06] Aircraft [SA120] Aeronautical engineering [SA63] Ozone deplection	[103]
104	OFELIA	Yes	-	Yes	[SA196] SMR Open-Fan engine architecture	[104]
105	OHPERA	-	Yes	-	[SA51] Aliphatic compounds [SA51] Aliphatic compounds [SA43] Sustainable economy	[105]
106	OPTHYCS	-	Yes	-	[SA108] Control systems [SA110] Hydrogen energy [SA03] Air traffic management	[106]
107	OVERLEAF	-	Yes	-	[SA73] Energy and Fuels [SA43] Sustainable economy [SA06] Aircraft [SA182] Reduced life-cycle GHG emissions	[107]
108	PERF-AI	-	-	-	[SA37] Meteorology [SA06] Aircraft [SA42] Statistics and probability [SA73] Energy and Fuels [SA22] Machine learning	[108]

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Technologies, concepts and scientific areas vs CLAIM main topics (7/9)

Index	Project	CLAIM Main HE	H2Av	MorE	Technology, concept and/or science area	Ref.
109	PHIVE	Yes	-	-	[SA33] Internet of Things	[109]
110	PHP2	Yes	-	-	[SA130] Thermodynamic engineering [SA06] Aircraft [SA187] Computational science [SA188] Simulation software	[110]
111	PIONEER	-	-	-	[SA33] Internet of Things [SA107] Additive manufacturing [SA39] Production economics	[111]
112	2 EADPJ.01-W	-	-	-	[SA100] Automatic CTA [SA88] Enhanced safety [SA89] Improve predictability [SA91] Reduced fuel consumption and emissions	[112]
113	2 AARTPJ.02-W	-	-	-	[SA101] Surface route planning [SA102] Operation management [SA89] Improve predictability [SA91] Reduced fuel consumption and emissions	[113]
114	PJ.06-01	-	-	-	[SA103] OTM [SA89] Improve predictability [SA91] Reduced fuel consumption and emissions	[114]
115	PJ.07-W2-38	-	-	-	[SA93] Trajectory definition [SA94] Network management [SA91] Reduced fuel consumption and emissions	[115]
116	PJ.07-W2-40	-	-	-	[SA92] MTM [SA86] Cost efficiency [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[116]
117	.09-W2-44 #2	-	-	-	[SA87] DAC [SA86] Cost efficiency [SA88] Enhanced safety [SA89] Improve predictability [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[117]
118	2 PROSAPJ.10-	-	-	-	[SA99] Collaborative control [SA86] Cost efficiency [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[118] [166]
119	PJ.18-W2-53A	-	-	-	[SA97] Planning automation [SA98] Separation management [SA86] Cost efficiency [SA88] Enhanced safety [SA91] Reduced fuel consumption and emissions	[119]
120	PJ.18-W2-56	-	-	-	[SA95] Air-to-Ground trajectory synchronisation [SA96] CPDLC clearances [SA86] Cost efficiency [SA88] Enhanced safety [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[120]
121	PJ.18-W2-57	-	-	-	[SA94] Network management [SA86] Cost efficiency [SA88] Enhanced safety [SA91] Reduced fuel consumption and emissions	[121]
122	PJ.38-01	-	-	-	[SA85] ADS-C [SA86] Cost efficiency	[122]
123	POMZAB	Yes	-	Yes	[SA19] Electric batteries [SA27] Electric vehicles [SA52] Inorganic compounds [SA20] Alkali metals	[123]
124	PSIONIC	Yes	-	-	[SA19] Electric batteries [SA08] Renevable energy [SA27] Electric vehicles [SA20] Alkali metals [SA84] Polymer science	[124]
125	PULSELiON	Yes	-	-	[SA19] Electric batteries [SA27] Electric vehicles	[125]
126	RAISE	Yes	-	-	[SA64] Productivity [SA21] Data processing	[126]

Technologies, concepts and scientific areas vs CLAIM main topics (8/9)

Index	Project	CLAIM Main HE	H2Av	MorE	Technology, concept and/or science area	Ref.
127	RAPTOR	-	-	-	[SA06] Aircraft [SA22] Machine learning [SA02] Air pollution engineering	[127] [167] [168] [169]
128	ROAD TRHYP	-	Yes	-	[SA135] Composites [SA73] Energy and Fuels [SA43] Sustainable economy	[128]
129	SEATBELT	Yes	-	Yes	[SA51] Aliphatic compounds [SA19] Electric batteries [SA125] Nano-materials [SA27] Electric vehicles [SA20] Alkali metals	[129]
130	SeNSE	Yes	-	Yes	[SA19] Electric batteries	[130]
131	SIENA	Yes	-	-	[SA06] Aircraft [SA22] Machine learning	[131]
132	SiGNE	Yes	-	-	[SA19] Electric batteries [SA43] Sustainable economy	[132]
133	SiLiS	Yes	-	Yes	[SA19] Electric batteries [SA27] Electric vehicles [SA08] Renevable energy [SA20] Alkali metals	[133]
134	SJU Ref.: 10	-	-	-	[SA106] Optimised Route network [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[134]
135	SJU Ref.: 11	-	-	-	[SA105] CDO [SA91] Reduced fuel consumption and emissions	[135]
136	SJU Ref.: 33	-	-	-	[SA104] Free routing for flight [SA90] Optimised capacity [SA91] Reduced fuel consumption and emissions	[136]
137	SMART BATTERY	Yes	-	Yes	[SA08] Renevable energy	[137]
138	SmartOptoelectronics	-	Yes	Yes	[SA119] Fuel cells [SA08] Renevable energy [SA117] Energy conversion	[138]
139	SMR ACAP	Yes	Yes	Yes	[SA129] SMR architecture [SA01] Aeronautical engineering [SA06] Aircraft [SA177] Hydrogen propelled concept [SA178] SAF propelled concept	[139] [158]
140	SOLiD	Yes	-	-	[SA123] Manufacturing engineering [SA19] Electric batteries [SA77] Coating and films	[140]
141	SOLIFLY	Yes	-	Yes	[SA19] Electric batteries	[141]
142	SPARE	Yes	-	-	[SA06] Aircraft [SA112] Automation	[142]
143	SPARTAN	Yes	-	Yes	[SA06] Aircraft [SA33] Internet of Things [SA65] Power engineering	[143]
144	STORMING	-	Yes	-	[SA62] Catalysis [SA125] Nano-materials [SA107] Additive manufacturing	[144]

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Technologies, concepts and scientific areas vs CLAIM main topics (9/9)						
		CLAIM Main				
Index	Project	HE	H2Av	MorE	Technology, concept and/or science area	Ref.
145	SUPERZINC	Yes	-	Yes	[SA135] Composites [SA57] Transition metals [SA58] Alkaline earth metals	[145]
146	SWITCH	Yes	-	-	[SA06] Aircraft [SA43] Sustainable economy [SA02] Air pollution engineering [SA51] Aliphatic compounds [SA181] Hybrid water-enhanced turbofan	[146] [158]
147	TheMa4HERA	Yes	-	-	[SA55] Electric energy [SA111] Heat engineering [SA06] Aircraft [SA187] Thermal management system [SA188] Cabin air supply [SA189] Conditioning [SA190] Distribution Hybrid electric system cooling	[147] [158]
148	THERMAC	Yes	Yes	Yes	[SA49] Avionics cooling	[148]
149	THERMOBAT	Yes	-	-	[SA08] Renevable energy [SA60] Alcohols [SA115] Combined heat and power	[149]
150	TULIPS	Yes	Yes	Yes	[SA06] Aircraft [SA02] Air pollution engineering [SA07] Airport engineering [SA119] Fuel cells	[150]
151	ULICBat	Yes	-	Yes	[SA19] Electric batteries [SA08] Renevable energy [SA27] Electric vehicles	[151]
152	UNIFIER19	-	-	Yes	[SA06] Aircraft	[152]
153	NPRECEDENTE	Yes	Yes	Yes	[SA17] Climatic changes [SA73] Energy and Fuels [SA11] Biofuels	[153]
154	Up Wing	-	-	Yes	[SA73] Energy and Fuels [SA06] Aircraft [SA179] Ultra performance wing [SA180] Integrated HAR SAF Wing	[154] [158]
155	WATTsUP	-	-	Yes	[SA26] Ecosystems [SA130] Thermodynamic engineering [SA06] Aircraft	[155]

Table 7: List of acronyms

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CLAIM - List of acronyms (1/2)

Index	Acronym	Description
1	A&Dac	Advanced and/or Disruptive Aircraft Concept
2	AA	Aircraft Architecture
3	AC	Aircraft
4	Adg.RF	Adjusted radiative forcing
5	Adv&Dsr-Cnp	Advanced and Disruptive-Concept
6	AeroAcst	Aero Acoustics
7	Aerodyn	Aerodynamic
8	Arch	Architecture
9	AS	Aviation sector
10	ASAB	Aeronautics Systems Analysis Branch
11	Assess	Assessment
12	ATM	Air Traffic Management
13	ATR	Average Temperature Response
14	aUC#i	Alernative Use Case (with i=1 to N)
15	Bnft	Benefit (Considered)
16	BnftDev	Benefit Development
17	BnftScp	Benefit Scope
18	BnftUnc	Benefit Uncertainties (considered)
19	BrndFrst	Burned forest extension
20	bUC	Best Use Case
21	CA	Clean Aviation
22	CA-JU	Clean Aviation JU
23	CLAIM	Clean Aviation Impact Monitor
24	CleanH2	Clean Hydrogen
25	Clima	Climatological impact mitigation
26	Cloud%	Cloudiness coverage
27	ClssWT	Classic Wing-Tube Architecture
28	ClssWT	Classic Wing-Tube
29	Cnp	Concept
30	CntrEms	Contrails emissions
31	CoastLs	Coast territory losses
32	CoastPop	Coast population forced to emigrate
33	Ctg	Category
34	Demo	Demonstrator
35	Demo	Demonstration
36	Drct	Direct
37	DT	Digital tooling
38	eCTOL	electric Conventional Take-Off and Landing
39	Efct.RF	Effective radiative forcing
40	EGWP	Efficacy-weighted global warming potential
41	EISc	Entry in Service (Conservative)
42	EISp	Entry in Service (Progressive)
43	EMP	Estimated Market Penetration
44	Empn	Empennage
45	Emsn	Emission
46	EmsnLoc	Location of Emission
47	Eng	Engine
48	Env	Environmental impact mitigation
49	EnvImp	Environmental impact
50	eOther	Electric Other (e.g. Categories)
51	eOthers	eOthers "electric Other Categories
52	eSTOL	Electric Short Take-Off and Landing
53	EV-TA	Electric Vehicle-Test Aircraft
54	eVTOL	Electric Vertical Take-Off and Landing
55	ExtrEvnts	Number of extreme events
56	FlghWing	Flight Wing
57	Fuse	Fuselage
58	Gear	Gear
59	GTP	Global temperure change potential
60	GWP	Global warming potential

CLAIM - List of acronyms (2/2)

Index	Acronym	Description
61	H	High level
62	H2020	Horizon 2020
63	H2Av	Hydrogen for Aviation
64	HE	Hybrid-Electric
65	HER	Hybrid-Electric Regional (Aircraft)
66	HER-Cnp	Hybrid Electric Regional-Concept
67	HmLos	Number of Human losses due to extreme events
68	HyPwr	Hydrogen-powered aircraft
69	IceCont	Continental glacier extension reduction
70	IceRed	Glacier extension reduction
71	IndPrc	Industrial Processes
72	Indrct	Indirect
73	Intr	Interdipendence
74	L	Low level
75	LH	Long-Haul
76	LH-AC	Long-Haul Aircraft
77	LH-Cnp	Long Haul-Concept
78	Life	Lifetime
79	LiftBody	Lifting-Body
80	LM	Low-Medium level
81	M	Medium level
82	MH	Medium-High Level
83	mmRainFall	Number of mm of rain fell
84	MorE	More Electric
85	MrkSeg	Market Segment
86	Mtd	Methodology
87	MultiEng	Distribuited Multi-Engine
88	nUC	nominal Use Case
89	Opr	Operation
90	OW-Ph	Ocean water PH variations
91	Prp	Propulsion
92	RainFall	Number of rainfall events
93	Ref	Reference
94	RF-MeanTime	Mean time between rainfall events
95	RL	Rules
96	S/D	Science/Discipline
97	SA	Science application
98	SE	Single Engine
99	SeaLev	Sea level variations
100	Serv	Service
101	SESAR	Single European Sky Atm Research
102	ShDescr	Short description
103	SMR	Short & Medium Range
104	SMR-Cnp	Short & Medium Range-Concept
105	SnglEng	Single Engine
106	Soc&Ecn	Social and Economic development
107	Str	Structure
108	StrtBrsdWing	Strut Braced Wing
109	SuperLam	Super-Laminar body
110	Sys	System
111	Tatm	Atmospheric temperature
112	TBD	To be Defined
113	Tech	Technology
114	TRL	Technological Readiness Level
115	Trnsv	Tranversal
116	UE-SMR	Ultra-efficient Short-Medium Range (aircraft)
117	UE-SR	Ultra-efficient Short Range (aircraft)
118	ValTsk	Validation Task
119	Vhc	Vehicle
120	VLD	Very Large Demonstrator

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APPENDIX F: RELEVANT TEST AIRCRAFT AND DEMONSTRATORS

Table 8: List of test aircraft, demonstrators and infrastructures

CLAIM - Test Aircraft & Demonstrators (10/May/2024)							
Index	Aircraft/ Demonstrator Name	Organisation	Category	Configuration	Note	Use	Source references
1	Accel	-	-	-	Power Battery Pack - Demonstrator	-	
2	ARUP	-	-	Infrustructure	Urban-Air Port's Air One	Fist demonstrator hub	
3	Skyports	Skyports, Bicester	-	-	Country: UK Infrustructures	Air Taxi Urban Air Mobility	https://skyports.net/ https://skyports.net/skyports-and-bicester-motion-unveil-plans-for-uks-first-vertiport-testbed-for-air-taxi-industry/
4	ZEROe	Airbus	-	Twin-engine	Turbofan Demonstrator (2000 nm) H2 Powered (Hydrogen Fuel cell system 1.2 MW) Road map to 2035	Hydrogen powered aircraft Short Medium Range	https://www.airbus.com/en/newsroom/stories/2024-01-first-zeroe-engine-fuel-cell-successfully-powers-on https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
5	Blended-Wing Body (BWB)	Airbus	-	Twin-engine	Blended-Wing Body Concept H2 Powered	Hydrogen powered aircraft	https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
6	ZEROe (FlightLab)	Airbus	-	Four-eEngine	Demonstrator A380 platform	Hydrogen powered aircraft	https://www.airbus.com/en/newsroom/stories/2022-02-the-zeroe-demonstrator-has-arrived
7	Hydrogen Hub	Airbus	-	-	Infrustructure Airport Hydrogen Hub concept		https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
8	ERA	Acora Aero	-	-		-	
9	ePLANE	AeroTech, NASA	-	-	MagniX (Powered by) All electric eCaravan Cessna 208B platform	NASA's Electric Powertrain Flight Demonstrator	https://aerotec.com/category/magnix/ https://aerotec.com/wp-content/uploads/2022/12/first-flight-of-the-ecaravan-magnixs-all-electric-c208-technology-demonstrator.pdf
10	BLADE	Airbus	-	Breakthrough aircraft	Laminar flow wing demonstrator		
11	CityAirbus Demonstrator	Airbus	-	-	-	-	
12	E-Aircraft System House (EAS)	Airbus	-	-	Test facility	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
13	EcoPulse	Airbus	-	-	-	-	
14	Alia-250 Aircraft	Beta Technologies	-	-		-	https://amprius.com/evtol/
15	Explorer (B787)	Boeing	-	Twin-engine	Eco Demonstrator B787-10 platform 19 Techno Sectors under exploration	-	https://investors.boeing.com/investors/news/press-release-details/2023/Boeing-Expands-ecoDemonstrator-Flight-Testing-with-Explorer-Airplanes-Announces-2023-Plan/default.aspx
16	Explorer (B777)	Boeing	-	Twin-engine	Eco Demonstrator B777-200ER platform 19 Techno Sectors under exploration	-	https://www.aerosociety.com/news/innovate-collaborate-accelerate-boeing-s-ecodemonstrator-programme-examined/
17	Explorer (B737)	Boeing	-	Twin-engine	Eco Demonstrator B737-10 platform 19 Techno Sectors under exploration	-	https://www.boeing.com/sustainability/environment/ecodemonstrator
18	X-66A	Boeing, NASA	-	Twin-engine	Sustainable Flight Demonstrator MD90-30 Platform Transonic Truss-Braced Wing	-	https://www.nasa.gov/directorates/armd/iasp/sfd/
19	328eco	Deudesche Aircraft	-	Twin-engine	Technology demonstrator	Regional Air Mobility	https://deutscheaircraft.com/products/d328eco
20	E-Jet Freight	Embraer	-	Twin-engine	P2F Flight	Cargo carrier	
21	HEPS Aircraft (Diamond DA36 E-Star)	GE, Siemens, EADS, Diamond Aircraft	-	Twin-engine	-	Short Medium Range	https://to70.com/hybrid-electric-aircraft-a-technical-overview/
22	ES-30	Heart Aerospace (HEA)	-	-	-	Short Medium Range	https://amprius.com/hybrid-electric-aircraft/
23	Spartan Demonstrator (C27J)	Leonardo	-	-	Regional Integrated demonstrator Platform	Regional	
24	Spartan Fuselage mokup (C27J)	Leonardo	-	-	Regional Integrated demonstrator Platform -Fuselage Mokup	Regional	
25	S5	MTP	-	-	Electric Airplane		

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CLAIM - Test Aircraft & Demonstrators (10/May/2024)							
Index	Aircraft/ Demonstrator Name	Organisation	Category	Configuration	Note	Use	Source references
26	ATR class (TBD)	NASA	-	-	-	Short Medium Range	https://oig.nasa.gov/wp-content/uploads/2023/12/ig-23-014.pdf
27	MaxWell	NASA, Tecnam	-	-	Based on Tecnam 2006T	-	
28	Otto Celera 500L	Otto Aviation	-	Business Jet	Proof of concept-Super laminar	Short Medium Range	https://www.ottoaviation.com/
29	Otto Celera 800	Otto Aviation	-	Business Jet	Super laminar flight demonstrator	Short Medium Range	https://www.ottoaviation.com/
30	Dash 8-100	Raytheon Technology (Former United Technology)	-	-	Hybrid electric testbed	Short Medium Range	https://to70.com/hybrid-electric-aircraft-a-technical-overview/
31	United Airline Venture (VAV)	Sustainable Flight Found	-	-	To expand SAF adoption		
32	X-57 P2006T	Tecnam, NASA	-	-	-	Short Medium Range	https://www.hdi.global/globalassets/_local/international/downloads/specialty/aviation/e-flight_whitepaper.pdf
33	CASSIO	VoltAero, KinectAir	-	-	Hybrid-Electric Aircraft	Short Medium Range	https://www.voltaero.aero/press-releases/cassio-fractional-ownership-kinectair/
34	Hybrid-Electric Flight Demonstrator	Raytheon Technologyies	-	-	First engine run 2023	Regional Jet	https://www.mobilityengineeringtech.com/component/content/article/47373-raytheon-completes-first-engine-run-of-hybrid-electric-flight-demonstrator https://skiesmag.com/news/raytheon-technologies-completes-first-engine-run-regional-hybrid-electric-flight-demonstrator/
35	Iron-bird	RR, YASA	-	-	Ground Testbed		
36	Hyflyer	Zero Avia	-	-	Based on Piper AC		
37	YUGO Platform	Yugo	-	-			
38	eCTOL	ALIA	eCTOL	-	-	Short Medium Range	https://www.greenairnews.com/?p=5086
39	APUS	APUS Group (RR, BTU)	eSTOL	Classic bi-tail	Hybrid Vehicle High energy density pack + M250 Gas Turbine engine Distribuited propulsion		https://group.apus-aero.com/zero-emission/ https://www.md80.it/2019/11/06/rolls-royce-annuncia-un-nuovo-hybrid-electric-flight-demonstrator-realizzato-con-i-brandenburg-partners/
40	APUS i2 H2CELL	APUS Group (RR, BTU)	eSTOL	Twin-engine	Zero emission aircraft Powered by Hydrogen Fuel Cells	GA aircraft (500 nm)	https://group.apus-aero.com/zero-emission/ https://group.apus-aero.com/wp-content/uploads/2023/10/APUS_i-2_Broschuere_20231027_Web.pdf
41	Multi mission version	APUS Group (RR, BTU)	eSTOL	Four-eEngine	All electric (H2 Fuel cells and Batteries)	Regional Air Mobility Multi mission	https://group.apus-aero.com/zero-emission/
42	APUS i5 Hydrogen A	APUS Group (RR, BTU)	eSTOL	Four-eEngine	Cargo carrier Installed Power 4x150KW (H2 Fuel cells and Batteries)	Regional Air Mobility	https://www.sxi.aero/wp-content/uploads/2022/06/APUS_i-5.pdf https://group.apus-aero.com/zero-emission/ https://group.apus-aero.com/wp-content/uploads/2023/10/APUS_i-5_Broschuere_20231027_Web.pdf
43	APUS i5 Hydrogen B	APUS Group (RR, BTU)	eSTOL	Four-eEngine	Passenger carrier Installed Power 4x150KW (H2 Fuel cells and Batteries)	Regional Air Mobility	https://www.sxi.aero/wp-content/uploads/2022/06/APUS_i-5.pdf https://group.apus-aero.com/zero-emission/
44	BAe 146 STA	BAE	eSTOL	Four-eEngine	Electric propulsion Demonstrator Flight Testbed	Short Medium Range	https://press.siemens.com/global/en/feature/major-joint-project-towards-electrification-aviation https://www.ainonline.com/aviation-news/air-transport/2017-11-28/airbus-lead-bae-146-electric-propulsion-demonstration
45	ZEROe H2 Energy	Airbus	eSTOL	Twin-engine	Turboprop Demonstrator H2 Powered	Hydrogen powered aircraft Short Medium Range	https://www.clean-aviation.eu/ultra-efficient-short-medium-range-aircraft https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
46	Fully Electric	Airbus	eSTOL	Six-Eengine	All electrical concept	Regional Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
47	CriCri	Airbus, Aero	eSTOL	Multicopter	All electric Acrobatic	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight https://www.icas.org/ICAS_ARCHIVE/ICAS2016/data/papers/2016_0731_paper.pdf
48	E-Fan 1.0	Airbus	eSTOL	Twin-engine	Full-electric Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
49	E-Fan 1.1	Airbus	eSTOL	Twin-engine	Full-electric Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
50	e-Genius	Airbus	eSTOL	Single-engine	Glider	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight

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CLAIM - Test Aircraft & Demonstrators (10/May/2024)							
Index	Aircraft/ Demonstrator Name	Organisation	Category	Configuration	Note	Use	Source references
51	EcoPulseTM	Airbus, Daher, Safran, CORAC and DGAC	eSTOL	Multi-eEngine	Distribuited Hybrid propulsion Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
52	Pangea (SY30J)	AirCraft Company	eSTOL	Four-eEngine	Concept design Hybrid-electric regional airplane	Regional air Mobility	https://theaircraftcompany.org/
53	Bleriot	Beyond Aero	eSTOL	Single-eEngine	Ultralight Vehice G1 H2 Power Source	-	https://pilotweb.aero/news/beyond-aero-makes-frances-first-manned-hydrogen-electric-flight/
54	Bleriot (BYA-1)	Beyond Aero	eSTOL	Single-eEngine	Propelled by 2 Turbojet	-	https://www.flightglobal.com/aerospace/beyond-aero-claims-frances-first-manned-hydrogen-powered-flight/157195.article
55	EL-2 Goldfinch	Electra.Aero	eSTOL	Eight-eEngine	Hybrid-Electric Flight Demonstrator	Short Medium Range	https://www.electra.aero/news https://www.avweb.com/aviation-news/electra-unveils-hybrid-electric-stol-demonstrator/
56	Ampaires 208B Grand Caravan	GE, Siemens, EADS, Cessna	eSTOL	Twin-engine	Ground tested Retrofit of Cesnna 337 Skymaster	Short Medium Range	https://to70.com/hybrid-electric-aircraft-a-technical-overview/
57	Electra	Electra Aero	eSTOL		Cessna 172 Platform		
58	FLYV Platform	Fly Virtual Global (FLYV)	eSTOL		Hybrid Electric Aircraft Tecnam P2012 STOL	Small Regional Aircraft (400nm)	https://green.simplifying.com/p/flyvs-ambitious-plan-to-deploy-100
59	PHA-ZE 100	Jekta	eSTOL	-	Country: Switzerland Distribuited propulsion Hydroplane 19 Pax	Zero emissions Regional Air Mobility	https://jekta.swiss/
60	AirisOne	Airis Aerospace	eVTOL	-	Demonstrator	Urban Air Mobility	https://evtol.news/airisone/
61	Ava XC	Beta Technologies	eVTOL	Multicopter	Technology demonstrator	Urban Air Mobility	https://www.beta.team/timeline/
62	ALIA's Iron Bird	Beta Technologies	eVTOL	Multicopter	Technology demonstrator	Urban Air Mobility	https://www.beta.team/timeline/
63	"ThunderDome"	Beta Technologies	eVTOL	Multicopter	Full scale simulator	Urban Air Mobility	https://www.beta.team/timeline/
64	SA1	Hyundai	eVTOL	Four-eEngine	Electric propulsion Conceptual design	Air Taxi Urban Air Mobility	-
65	Z-300	ACS Aviation	eVTOL	Multicopter		Technology Demonstrator Fully electric	https://evtol.news/acs-aviation-z-300/
66	AE200 X01	Aerofugia Technoology Co. Ltd.	eVTOL	Multicopter	Country: China Demonstrator	Air Taxi Urban Air Mobility	https://evtol.news/aerofugia-technology-co-ltd-geely-ae200-x01-technology-demonstrator
67	aG-4 Liberty	aeroG Avuiation LLC	eVTOL	-	-	-	https://evtol.news/aerog-aviation-ag-4/
68	Air One	AIR	eVTOL	Multicopter	Concept demonstrator	Air Taxi Urban Air Mobility	https://evtol.news/airisone/
69	CityAirbus	Airbus	eVTOL	Multicopter	Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
70	CityAirbus Next-Gen	Airbus	eVTOL	Multicopter	Concept	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/urban-air-mobility
71	Vahana	Airbus	eVTOL	Multicopter	Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight
72	Vahanna Alpha One	Airbus Acubes	eVTOL	Multicopter	Demonstrator	-	https://evtol.news/a3-by-airbus/
73	Vahanna Alpha Two	Airbus Acubes	eVTOL	Multicopter	Demonstrator	-	https://evtol.news/acubed-vahana-alpha-two-defunct
74	Vahanna Beta	Airbus Acubes	eVTOL	Multicopter	Concept design	-	https://evtol.news/airbus-acubed-vahana-beta-concept-design
75	E-Fan X	Airbus, Siemens, RR	eVTOL	Multicopter	Demonstrator	Urban Air Mobility	https://www.airbus.com/en/innovation/low-carbon-aviation/hybrid-and-electric-flight https://press.siemens.com/global/en/feature/major-joint-project-towards-electrification-aviation

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CLAIM - Test Aircraft & Demonstrators (10/May/2024)							
Index	Aircraft/ Demonstrator Name	Organisation	Category	Configuration	Note	Use	Source references
76	Maker	Arcer Aviation Inc.	eVTOL	Multicopter	Technology Demonstrator	Urban Air Mobility	https://evtol.news/archer-maker
77	Midnight	Arcer Aviation Inc.	eVTOL	Multicopter	Production aircraft	Urban Air Mobility	https://www.ainonline.com/news-article/2022-12-01/archer-achieves-first-full-transition-flight-its-maker-evtol-demonstrator https://evtol.news/archer/ https://investors.archer.com/news/news-details/2022/Archer-Unveils-its-Production-Aircraft-Midnight/default.aspx
78	Prosperity	AutoFlight	eVTOL	-		-	https://english.news.cn/20240228/a6b264b6d7cd4903a20c2857d2f92119/c.html
79	Y6S	Autonomous Flight	eVTOL	-		-	http://evtol.news/autonomous-flight/
80	Y6S Plus	Autonomous Flight	eVTOL	-		-	https://evtol.news/autonomous-flight-y6s-plus
81	Avioneo 2345	Avioneo Robotics	eVTOL	-		-	https://evtol.news/avioneo-robotics-avioneo-2345
82	B5	Baaz	eVTOL	Multicopter	Country: Germany	Urban Air Mobility	https://evtol.news/baaz-production-model
83	Bartini	Bartini Aero Inc.	eVTOL	Multicopter	Technology demonstrator	Urban Air Mobility	https://evtol.news/bartini-technology-demonstrator
84	Bartini	Bartini Aero Inc.	eVTOL	Multicopter	Production aircraft	Urban Air Mobility	http://evtol.news/bartini/ https://bartini.aero/
85	APT	Bell	eVTOL	Multicopter	Autonomous Pod Transport	-	https://evtol.news/bellapt/
86	Nexus 6HX	Bell	eVTOL	Multicopter	Concept design	Air Taxi Urban Air Mobility	https://evtol.news/bell-nexus-4ex/
87	Nexus 6HX ...	Bell	eVTOL	Multicopter	Concept (TBV)	Air Taxi Urban Air Mobility	https://evtol.news/bell-air-taxi
88	Ava XC	Beta Technology, Inc.	eVTOL	Multicopter	Technology demonstrator	Air Taxi Urban Air Mobility	https://evtol.news/beta-technologies-prototype/
89	Chongquin	Chongquin Innovation Center	eVTOL	Multicopter	Flight Car - Prototype	Air Taxi Urban Air Mobility	https://evtol.news/chongqing-flying-car-prototype
90	Concept Integrity	Crisalion Mobility	eVTOL	Multicopter	Prototype	Urban Air Mobility	https://evtol.news/umiles-next-concept-integrity
91	New concept	Crisalion Mobility	eVTOL	Multicopter	Prototype	Urban Air Mobility	https://evtol.news/crisalion-mobility-new-concept-2
92	Bumble Bee	Cyclo Tech GmbH	eVTOL	Multicopter	Technology demonstrator	Urban Air Mobility	https://evtol.news/cyclotech-bumble-bee
93	DroFire (UAD M20)	Digi Robotics	eVTOL	-	Drone	-	https://evtol.news/digi-robotics-droxi/
94	DroFire (UAD M470)	Digi Robotics	eVTOL	-	Drone	-	http://evtol.news/digi-robotics-drofire/
95	aEro 2	Dofour Aerospace	eVTOL	Multicopter	Drone - Cargo carrier	-	https://www.dufour.aero/aero2 https://evtol.news/dufour-aero2/
96	VTOL Technology Demonstrator	Dofour Aerospace	eVTOL	Multicopter	Technology Demonstrator	Urban Air Mobility	https://evtol.news/dufour-aerospace-vtol-technology-demonstrator
97	EH216	Ehang	eVTOL	Multicopter	Technology demonstrator	Urban Air Mobility	https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/
98	Y6	Electric Aerospace	eVTOL	Multicopter	-	-	https://evtol.news/electric-airspace-y6
99	Elytron 2S P	Elytron Aircraft LLC	eVTOL	Twin-engine	Prototype 12	-	https://evtol.news/transcend-elytron-2s-prototype-11
100	EVE (TBV)	EVE Air Mobility	eVTOL	Multicopter	Concept design, MockUp	-	https://www.eveairmobility.com/evtol/ https://www.eveairmobility.com/#s8

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CLAIM - Test Aircraft & Demonstrators (10/May/2024)							
Index	Aircraft/ Demonstrator Name	Organisation	Category	Configuration	Note	Use	Source references
101	Valiant	Griffon Aerospace	eVTOL	Multicopter	Prototype	Cargo carrier	https://evtol.news/griffon-aerospace-valiant
102	Joby S4	Joby aviation	eVTOL	-	Production prototype	-	https://evtol.news/joby-aviation-s4-production-prototype https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/
103	Joby S4 1.0	Joby aviation	eVTOL	-	Technology demonstrator	Urban Air Mobility	https://evtol.news/joby-aviation-s4-10-technology-demonstrator
104	Joby S4 2.0	Joby aviation	eVTOL	-	Pre-production prototype	Urban Air Mobility	https://evtol.news/joby-s4
105	Monarc Personal Air Vehicle	Joby aviation	eVTOL	-	-	-	https://evtol.news/joby-s4-monarch/
106	Heaviside	Kitty Hawk Corporation	eVTOL	-	-	-	https://evtol.news/kitty-hawk-heaviside/
107	Night Intrudur (NI-500VYT)	Korea Aerospace Industries	eVTOL	-	Prototype	-	https://evtol.news/korea-aerospace-industries-night-intruder
108	Lilium Jet	Lilium Air Mobility	eVTOL	Multicopter	DEVT Demonstrator	Urban Air Mobility	https://lilium.com/jet https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/ https://www.easa.europa.eu/eco/eaer/topics/technology-and-design/drones-urban-air-mobility-vehicles https://lilium.com/
109	E20	Tcab	eVTOL	-	Half scale demonstrator	-	https://evtol.news/news/press-release-tcab-flies-e20-half-scale-demonstrator
110	VA-1X	Vertical Aerospace	eVTOL	-			https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/
111	Volocopter	Volocopter GmbH	eVTOL	Multicopter	-	Urban Air Mobility	https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/ https://www.easa.europa.eu/eco/eaer/topics/technology-and-design/drones-urban-air-mobility-vehicles
112	Volocopter 2X	Volocopter GmbH	eVTOL	Multicopter	-	Urban Air Mobility	https://www.easa.europa.eu/sites/default/files/dfu/uam-short-report.pdf
113	Cora	Wisk	eVTOL	-	Boeing+Kitty Hawk	-	https://interactive.aviationtoday.com/avionicsmagazine/february-march-2021/10-evtol-development-programs-to-watch-in-2021/
114	Trifan 600	XTI Aircraft	eVTOL	Multicopter	Hybrid-Electric Full electric as second step	Urban Air Mobility	https://www.xtiaircraft.com/
115	Vertical MAG	Bell	eVTOL	Tiltrotor	Autonomous Flight demonstrator Based on 429 Model	-	https://verticalmag.com/news/bell-reveals-autonomous-flight-demonstrator-based-on-429/
116	Starling Cargo (S5M)	ARC Aerosystems	eVTOL, eSTOL	Multicopter	Concept design Demonstrator 1st Experimental flight test	Urban Air Mobility	https://evtol.news/samad-aerospace-starling-cargo-s5m-demonstrator
117	Tindair	INNOV ATM	eVTOL, eVTOLS	-	Large Scale Demonstrator	U-Space Service Urban Air Mobility	https://www.sesarju.eu/projects/TINDAIR https://cordis.europa.eu/project/id/101017677
118	DisruptiveLab	NASA	Single rotor	Single Engine Light	Flight Laboratory	Urban Air Mobility	https://sacd.larc.nasa.gov/uam-refs/ https://sacd.larc.nasa.gov/wp-content/uploads/sites/167/2022/02/WhitesidePollard2022-Tiltduct.pdf
119	Eco Caravan	AMPAIRE, RED	STOL	Singe-engine	Experimental aircraft (Super Sky Master) RED Engine Hybrid-Electric with SAF 12th Flight tests performed	-	https://red-aircraft.de/ampaire-eco-caravan/ https://www.aviationtoday.com/2022/11/23/ampaires-hybrid-electric-grand-caravan-takes-flight/
120	HEA - ES30	Amprius Technologies	STOL	-	Hybrid-Electric Aircraft	Short range	https://amprius.com/hybrid-electric-aircraft/ https://amprius.com/evtol/ https://amprius.com/technology/ https://amprius.com/facility/ https://amprius.com/evtol/ https://amprius.com/about/
121	Do328eco	Deutsche Aircraft	STOL	-	D328 Platform using SAF	Short Medium Range	https://www.aircraft-commerce.com/wp-content/uploads/aircraft-commerce-docs/General%20Articles/2022/142_DEVELOP.pdf
122	Multi-Tiltrotor	NASA	Tiltrotor	Six-engine	Concept	Multi-modal mobility	https://sacd.larc.nasa.gov/uam-refs/ https://sacd.larc.nasa.gov/wp-content/uploads/sites/167/2022/02/WhitesidePollard2022-Tiltduct.pdf
123	Tiltrotor	NASA	Tiltrotor	Twin-engine	Concept	Multi-modal mobility	https://sacd.larc.nasa.gov/uam-refs/ https://sacd.larc.nasa.gov/wp-content/uploads/sites/167/2022/02/WhitesidePollard2022-Tiltduct.pdf
124	Trinity	Ace	VTOL	Multicopter	Long Range	Concept Design Advanced Air Mobility	https://evtol.news/ace-vtol-trinity-concept-design
125	Barracuda	Advanced Tactics	VTOL	Multicopter	Passenger Carrier Cargo Carrier	Fuel Hybrid-Electric power Fully electric	https://evtol.news/advanced-tactics-barracuda

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APPENDIX G: REFERENCES FOR OVERVIEW OF R&I PROJECTS AND RELEVANT TECHNOLOGIES

Table 9: References for Appendices D-F

CLAIM Project - List of References (1/5)		
Index	***Code***	***Link***
1	[001]	https://cordis.europa.eu/project/id/875033
2	[002]	https://cordis.europa.eu/project/id/875036
3	[003]	https://cordis.europa.eu/project/id/101069743
4	[004]	https://cordis.europa.eu/project/id/867907
5	[005]	https://cordis.europa.eu/project/id/101046870
6	[006]	https://cordis.europa.eu/project/id/101102020
7	[007]	https://cordis.europa.eu/project/id/101017702
8	[008]	https://cordis.europa.eu/project/id/875029
9	[009]	https://cordis.europa.eu/project/id/876828
10	[010]	https://cordis.europa.eu/project/id/865354
11	[011]	https://cordis.europa.eu/project/id/101076311
12	[012]	https://cordis.europa.eu/project/id/835073
13	[013]	https://cordis.europa.eu/project/id/101069705
14	[014]	https://cordis.europa.eu/project/id/101056885
15	[015]	https://cordis.europa.eu/project/id/101084066
16	[016]	https://cordis.europa.eu/project/id/101102000
17	[017]	https://www.cerise-project.eu/
18	[018]	https://cordis.europa.eu/project/id/101069750
19	[019]	https://cordis.europa.eu/project/id/101007715
20	[020]	https://cordis.europa.eu/project/id/101056868
21	[021]	https://cordis.europa.eu/project/id/101083944
22	[022]	https://cirrus-hl.de/
23	[023]	https://cordis.europa.eu/project/id/101140632
24	[024]	https://cordis.europa.eu/project/id/777035
25	[025]	https://cordis.europa.eu/project/id/190155898
26	[026]	https://climaviation.fr/en/
27	[027]	https://cordis.europa.eu/project/id/875503
28	[028]	https://cordis.europa.eu/project/id/875568
29	[029]	https://cordis.europa.eu/project/id/101101999
30	[030]	https://cordis.europa.eu/project/id/101092347
31	[031]	https://cordis.europa.eu/project/id/826182
32	[032]	https://cordis.europa.eu/project/id/831848
33	[033]	https://cordis.europa.eu/project/id/101043676
34	[034]	https://cordis.europa.eu/project/id/875504
35	[035]	https://cordis.europa.eu/project/id/101095457
36	[036]	https://cordis.europa.eu/project/id/101058100
37	[037]	https://www.econtrail.com/
38	[038]	https://cordis.europa.eu/project/id/190108462
39	[039]	https://cordis.europa.eu/project/id/101039748
40	[040]	https://cordis.europa.eu/project/id/101070856

CLAIM Project - List of References (2/5)		
Index	***Code***	***Link***
41	[041]	https://cordis.europa.eu/project/id/190114794
42	[042]	https://cordis.europa.eu/project/id/769241
43	[043]	https://cordis.europa.eu/project/id/101067998
44	[044]	https://cordis.europa.eu/project/id/785416
45	[045]	https://cordis.europa.eu/project/id/101057388
46	[046]	https://cordis.europa.eu/project/id/101056765
47	[047]	https://cordis.europa.eu/project/id/101086218
48	[048]	https://cordis.europa.eu/project/id/101101978
49	[049]	https://cordis.europa.eu/project/id/101101946
50	[050]	https://flyatm4e.eu/
51	[051]	https://cordis.europa.eu/project/id/101069890
52	[052]	https://cordis.europa.eu/project/id/101069293
53	[053]	https://cordis.europa.eu/project/id/101007968
54	[054]	https://cordis.europa.eu/project/id/865300
55	[055]	https://cordis.europa.eu/project/id/101072239
56	[056]	https://cordis.europa.eu/project/id/101091572
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