EASA

European Union Aviation Safety Agency

EASA Scientific Committee

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EASA Scientific Committee

Annual Report 2024

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Table of Content

Acronyms and Terminology

ANSP

AI	Artificial Intelligence
ANP	Academia Networking Platform
ANTF	Academia Network Task Force
CAT	Clear Air Turbulence
EASA	European Union Aviation Safety Agency
ECA&D	European Climate Assessment & Dataset
EDR	Eddy Dissipation Rate
EPAS	European Plan for Aviation Safety
IPCC	Intergovernmental Panel on Climate Change
MSCA	Marie Skłodowska-Curie Actions
MTOW	Maximum Takeoff Weight
PhD	Doctor of Philosophy
PIREPs	pilot reports
RCP	Representative Concentration Pathway
SciComm	Scientific Committee
SIGs	Special Interest Groups
SIGMA	System of Icing Geographic Identification in Meteorology for Aviation
TF	Task Force
TOD	Top of Descent
ToR	Terms of Reference

1 Executive Summary

The EASA Scientific Committee was established and became fully operational in 2022 with the objective to provide advice to the EASA Executive Director on scientific issues. Primary focus of advice are areas with the potential to influence the future development of the EASA expertise in scientific and technical domains linked to research, innovation, and disruptive technologies. The committee consists of a small number of internationally recognized experts covering relevant areas of expertise and having direct access to relevant academic stakeholders.

After its first two years of successful operation and delivery of the annual reports 2022 and 2023 the present document covers the reporting on the third operational year. The report provides evidence of the activities undertaken, the respective outcome and recommendations regarding future activities.

In 2024 the Scientific Committee continued its operation along the established working arrangements and provided support via efficient and lean processes following the agreed annual working cycle. According to the recommendations delivered in 2023 the 2024 cycle maintained the existing thematic areas addressing

- the development of a blue print for setting up and operating an EASA-Academia Networking Platform,
- the state of research regarding the impact of climate change on aviation, and
- perspectives of applying artificial intelligence level 2 and 3 in the air transport system.

The respective Task Forces were adjusted in terms of membership and continued delivering results relevant for short term actions as well as for long term strategic considerations.

In order to develop a structured approach to connect academia with EASA, and later potentially with other stakeholders, the scope of the former PhD Taskforce has been reviewed and refocused. Within the newly established **Academia Network Task Force (ANTF),** which replaces the former PhD Taskforce, the concept of an Academia Networking Platform (ANP) has been developed to enhance collaboration and leverage expertise, and to systematically identify and prioritise key research areas. As a result, a detailed blueprint with recommendations and a roadmap for implementation has been developed through a partnership with an existing knowledge transfer network.

The **Task Force on impact of climate change** has undertaken a review of scientific works on the trends regarding coastal flooding risk and its effects on aviation safety, heavy and extreme precipitation, as well as changes to jet streams and their impacts on weather patterns. For each type of weather hazard, they have reviewed the state of knowledge regarding past and future trends, and identified whether there are agreements between research works, and what are the main uncertainties and uncovered aspects. Overall, the work so far as resulted in a more than 200 pages document, which provides a unique foundation for anticipating the impact of climate change to aviation in order to guide possible future research.

The **AI Task Force** activity in 2024 has been instrumental for the EASA AI Programme, supporting the preparation of the report for the first AI Ethics Survey for aviation. The Committee provided guidance on the Concept paper (issue 2) concerning the Ethical based assessment, namely the definition of objectives not covered by the current regulations. In addition, the set of Human Factors objectives for Human-AI teaming were refined and a first set of principles for the development for Level 3A AI guidance (advanced automation) was anticipated. A reflexion on the alignment of the Level 3 AI principles with the EU AI Act Article 14 on 'Human Oversight' resulted in the preparation of a position paper supporting the discussions with the EU Commission on the way to orient the Level 3 guidance. In addition, relevant building blocks for Level 3 AI such as the concept of independent 'operational oversight system' and the related of monitoring tasks taken over by such system were explored. As a complementary activity, important criteria were investigated orienting the possible classification of operations in terms of their complexity on a model proposed NIST ALFUS.

In light of the fourth activity cycle in the year 2025, recommendations regarding the way forward on the current topics have been elaborated by the committee. Further potential thematic focus has been identified in the topics of climate impact on aviation, AI in aviation and academic networks.

The presented report describes the activities, key findings and recommendations issued by the Scientific Committee. A comprehensive appendix provides more detailed insights into the findings.

2 Introduction

The document summarises the activities of the EASA Scientific Committee in its third year of operation. It briefly recalls the background and motivation for the establishment of the Committee, its composition, internal procedures and working arrangements. The main focus of the report is on the three relevant organisational and scientific topics that have been taken over and continued from the first year, with some further development of their scope and objectives. These topics cover the following areas:

1. topic #1: Academia Networking Platform
2. topic #2: Impact of climate change
3. topic #3: Artificial Intelligence

For each of these topics, the document describes the methodology used, the work plan, its implementation and the results achieved so far. It also provides recommendations for two different timescales: Short-term "quick wins" are presented, which provide options for immediate consideration and implementation to take advantage of existing opportunities. Longer term recommendations are presented which can support EASA's strategic thinking. In addition, the way forward for the three initial topics is proposed, as well as the inclusion of other relevant topics in future cycles.

The purpose of this report is to preserve the findings of the SciComm and to provide a basis for its future work. It may provide guidance to EASA on specific topics and may serve the scientific community as a basis for considering future research directions. Finally, the state of the art in the selected research topics and the need for further research will be substantially elaborated. The results of the committee's work to identify the state of the art in relation to the impact of climate change on aviation and to identify relevant research gaps can serve as an example. The resulting documentation provides a solid basis for future work.

Finally, this report is intended to be the third in a series of annual reports recording the activities of the members of the Scientific Committee. It can provide evidence of the value of the Committee's contributions, both in the short term and at a strategic le

3 Mission, Composition and Organization of the EASA Scientific Committee

3.1 Mission

The EASA Scientific Committee (SciComm) was established in 2021 with the objective to provide advice to the EASA Executive Director on scientific issues that may influence the future development of the EASA expertise in scientific and technical domains linked to research, innovation, and disruptive technologies. Furthermore, the scientific committee members should advise the Executive Director as regards processes in aviation that may impact Aviation Safety, Environmental Protection, Security, and Aviation Health Safety.

The Committee and its members shall in particular advise the Executive Director on:

- how to best address the technical and scientific challenges EASA may be faced with through emerging concepts and innovative / disruptive technologies
- the digital evolutions and their potential mid-term impact on the EASA oversight processes
- scientific related matters concerning knowledge gaps, assessment of research results and new threats to aviation
- how to best address new societal evolutions in the aviation sector (of a nature affecting either technical developments or its business models)
- the seriousness of potential new risks/threats in Environmental protection
- the seriousness of potential new risks/threats in aviation health safety
- the effectiveness of technologies in reducing/mitigating these risks
- how to help promoting appropriate innovative processes and technological evolution (in or alongside the EASA EPAS)
- the directions of the Research activities that EASA could support, both in the domains of Excellence Science & Outreach and of Application Oriented Research
- how to facilitate the transfer of the EASA activities to the EASA regulatory, knowledge management, and implementation processes
- any other topic brought to the Committee by the EASA Executive Director

In order to fulfil this mission, an initial but not exclusive list of relevant scientific areas has been defined by EASA and the members of the SciComm have been selected through an open process ensuring an appropriate coverage of these areas. In addition, further roles like e.g., a sounding board with respect to new initiatives or as interfaces towards other scientific bodies are continuously assessed and discussed.

The background of founding the committee, its general mission, its tasks as well as relevant formal arrangements are described in further detail in the document “Terms of Reference”.

3.2 Composition

The members of the Scientific Committee have been appointed by the EASA Executive Director based on the list of independent external experts maintained by EASA as a result of Call for Expression of Interest EASA.2019.CEI.14. Members were chosen for their expertise, being mostly of academic nature, with direct access to universities, Academia and PhD networks.

EASA evaluated their competences to ensure commitment to the furthering of safety, environmental protection, security, research, innovation and aviation health safety activities through an adequate coverage and balance in terms of:

- Academic and/or Industrial expertise;
- Range of views and competencies within the scientific community (i.e. coverage of the most relevant scientific fields linked to the needs of the EASA activities);
- Experience in a range of relevant research and innovation activities with publications and/or public appearances, or PhD schemes

In December 2021, EASA appointed the chairman and members for the Committee for a duration of three years (2022-2024) in their personal capacity. As two of the initially eleven members decided at the end of 2022 to retire from the Committee for private reasons, the remaining experts carried on the activities.

In addition, one new member was selected along the same procedure as the initial members in order to further strengthen the profile of the committee in the area of meteorology. Prof. Dr. Silas Michaelides joined the Scientific Committee at the beginning of the 2024 working cycle.

Prof. Dr. Peter Hecker, Chairman	Vice President TU Braunschweig, Professor in Aerospace Engineering
Dr. Nicholas Asher	Director of the Artificial and natural Intelligence Toulouse Institutes
Prof. Frances Brazier	Professor at TU Delft in Intelligent systems
Prof. Marianna Jacyna	Dean of the Faculty of Transport, Warsaw University of Technology
Prof. Martin Kaltschmitt	Head of the Institute of Environmental technology and Energy economics
Dr. Christiane Schmidt	Senior Associate Professor, Communications and Transport Systems Division at the Department of Science and Technology (ITN) at Linköping University
Prof. Nicole Viola	Associate Professor of Aerospace Systems at Politecnico di Torino and Post-Graduate master programs with ISAE-Supaero and Leicester University
Prof. Marco Lovera	Leading the research laboratory of the Aerospace Systems and Control Laboratory at the University Politecnico di Milano advanced systems
Dr. Torben Hovald	Analysis and Monitoring Unit Team Leader, European Union Agency for Railways
Prof. Dr. Silas Michaelides	Adjunct Professor at the Cyprus Institute, affiliated with Climate and Atmosphere Research Center (CARE-C)

Table 1: Members of the Scientific Committee in 2024

3.3 Organization and Formation of Task Forces

In 2022 the SciComm had developed and implemented an internal process for organizing its workflow, i.e. the structuring, prioritizing and managing of activities along the Terms of Reference. This process had proven its suitability over the first year successfully supporting an efficient operation delivering maximum support to EASA in the first operational year. Therefore, it was maintained for 2023.

According to the recommendations provided in the 2022 report, the Committee decided to maintain and further develop the thematic focus on three topics also for 2023:

1. topic #1: Academia Networking Platform
2. topic #2: Impact of climate change
3. topic #3: Artificial Intelligence

In order to further evolve on these topics in an efficient manner, the existing Task Forces have been maintained and the membership has been adjusted according to the further evolution of the topics. An assignment list for 2024 is provided in table 2.

	Taskforce #1 Academia Networking Platform	**Taskforce #2 Impact of climate change**	**Taskforce #3 Artificial Intelligence**
EASA PoC	**Thomas Mickler**	**Guillaume Aigoin**	**Guillaume Soudain**
Prof. Dr. Peter Hecker	**X**		**X**
Dr. Nicholas Asher			**X**
Prof. Frances Brazier			**X**
Prof. Marianna Jacyna	**X**		**X**
Prof. Martin Kaltschmitt	**X**		
Dr. Christiane Schmidt		**X**	
Prof. Nicole Viola		**X**	
Prof. Marco Lovera			**X**
Dr. Torben Hovald			
Prof. Dr. Silas Michaelides		**X**	
Further EASA support	Valérie Landry-Sivel, Kirsti Reinartz-Krott, Colin Hancock, Emmanuel Isambert, Antonio Gonzales Gomes.		Renée Pelchen-Medwed, Mathilde Labatut, Andrew Kilner, Ines Berlenga, Axel Werner, Gilles Gardiol.

Table 2: Composition of Task Forces

Operation of Task Forces

The Task Forces further defined the scope of activities, the work programme and their objectives for 2024. In addition, the working methods, an appropriate timetable and the distribution of work among the members were developed. The Task Forces typically organised their activities through email exchanges, collaborative online workspaces and virtual meetings. They maintained contact with their

EASA PoC, which provided relevant material and involved additional EASA members as needed (see Table 2). The TFs gave brief progress reports during the SciComm meetings over the consultation period. At least one of the SciComm plenary meetings was scheduled as a physical presence meeting. This allowed a general awareness of the whole SciComm and ensured regular updates and involvement of all SciComm members.

At the end of the consultation period the Task Forces summarized their activities and provided input to annual report, which is requested according to the SciComm's Terms of Reference. In general, the reporting was a joint effort among all SciComm members specifically supported by the chairpersons of the SciComm and TF.

4 Report of Task Force #1: PhD Scheme Development / Academia Networking Platform

4.1 Introduction and Scope

EASA acknowledges the need to adapt regulatory approaches to rapid technological advancements in aviation, and has recognized the importance of strengthening partnerships with academia to advance aviation safety and innovation. To this end a "European_Academia @EASA" conference was held in March 2023, which aimed to foster closer relations between EASA and academic institutions. As one of the lessons learnt, both EASA and the Scientific Committee considered it beneficial to establish a permanent network with Academia to enhance cooperation by leveraging expertise and systematically identifying and prioritizing key research areas.

Building on this, an Academia Network Task Force (ANTF) was established on January 31, 2024, under the Scientific Committee, succeeding the PhD Task Force. The primary goal of the ANTF is to develop a structured Academia Networking Platform (ANP) that integrates academia, EASA, and later, potentially other stakeholders, to support EASA's mandate under Article 86 of the Basic Regulation (EU) 2018/1139.

In this context, the ANTF also sees a benefit to establish a foresight function that aims to anticipate future trends, align research priorities with EU frameworks, and prepare resources, training, and regulations for emerging technologies. It also emphasizes fair, democratic, and objective principles in decision-making and funding allocation.

This annual report summarizes the ANTF's 2024 objectives, challenges, progress, and a roadmap for the year 2025. The report highlights the potential value of an Academia Networking Platform for EASA and the broader aviation sector. Strategic funding and partnerships will be critical to transforming this vision into reality.

According to its TORs that were agreed in February 2025 the Academia Networking Task Force seeks to enhance collaboration between EASA, the academic community, and other stakeholders to advance research and innovation in civil aviation, aligned with Article 86 of Regulation (EU) 2018/1139. The task force aims to leverage academic expertise to identify emerging research themes and technologies, providing guidance to EASA, the European Commission, and Member States on addressing future-focused challenges in safety, efficiency, and sustainability. A critical focus is fostering interdisciplinary collaboration by bringing together insights from diverse fields such as engineering, environmental science, computer science and artificial intelligence, as well as human factors to address aviation's complex challenges holistically.

4.2 Work Plan and Methodology

To achieve these goals, the task force initiated a collaborative approach between its members in oder to develop in a comprehensive blueprint for an Academia Networking Scheme/Platform (ANP) that includes stakeholder engagement frameworks, online collaboration platforms, mentorship programs, and funding opportunities. The goal of this ANP is to align academic contributions with EU framework programmes for research and innovation, enhancing the impact and relevance of EU-funded projects. Additionally, it will promote the exploitation of research results by identifying practical applications and facilitating innovation through collaboration between academia, industry, and regulators. By supporting targeted ad hoc research activities, the AN TF will address immediate civil aviation challenges that align with EASA's objectives.

The AN TF met regularly throughout the year and had a total of 9 Webex meetings, including the final meeting of 2024 on 11th December 2024 to conclude on the final annual report and plan for 2025.

4.3 Key Findings in 2024

Concept Development:

In 2024, the AN TF established an inventory (overview) of relevant European research institutes across Europe and drafted a structured approach Blueprint for an EASA-Academia Networking Ecosystem. It outlines a proposal to create a collaborative platform to connect academia with EASA, addressing aviation challenges and fostering innovation, which also has a potential to contribute to a common platform for collaboration, particularly with SEASR Joint.

The platform concept includes a portal with both public and restricted access that serves as digital hub with databases, forums, and tools for collaboration, as well as thematic groups called Special Interest Groups (SIGs) for focused research on transformative topics. It proposes hosting annual high-level academic conferences to facilitate discourse on research priorities, leveraging funding mechanisms, and integrating governance by the EASA's scientific committee. The network aims to identify, highlight and bridge research, industry, and regulatory needs, ensuring alignment with aviation safety and technological progress.

The ANP Blueprint encompasses:

- Objectives:
  - Structuring collaboration frameworks.
- Operations:
  - Academic Networking Platform (ANP).
  - Special Interest Groups (SIGs).
  - Conferences, workshops, and webinars.
  - Funding mechanisms (e.g., MSCA, ENGAGE).
  - Data management and protection.
  - Communication and feedback processes.
- Governance:
  - Supervision guidelines for ANP and SIGs.
  - Procedural frameworks.

- Stakeholder Collaboration:
    - Proposed partnerships with existing frameworks, such as the SESAR JU ENGAGE project, to leverage resources and expertise.
    - Recognized synergies with entities like the European Aerospace Scientific Network (EASN) for expanded academic representation.

Key Benefits of the ANP:

An Academia Networking Platform (ANP) will gather the collective knowledge in the field of aviation related research and provide and support foresight and preparedness for regulatory adaptations required by technological innovations. It will bridge academia, and EASA and help determine the future of regulatory needs to ensure safety and sustainability in aviation. It will also provide a democratic and objective platform for academia to contribute to policy development and help direct research funding to support the most promising and strategically important research areas.

The group sees value of including industry stakeholders in the ANP initiative at the right point in time, but for now the focus should remain on academia and regulatory bodies.

Challenges Identified:

The challenges facing this initiative are multifaceted. Funding and resource allocation are critical hurdles, while securing stable, long-term financial support is essential for the success of the initiative. Options that were looked at included:

- budget allocations within EASA,
- membership fees from participating institutions,
- grants or financial backing from the European Commission, and
- partnerships, particularly with SESAR JU, to co-finance and extend the ENGAGE initiative.

Partnerships were seen as a strategic way forward, aiming to integrate the new platform within established ecosystems to avoid duplicating efforts. Among these, collaboration with SESAR JU under the ENGAGE2 framework emerged as the most practical option, offering reduced development costs and access to established networks.

Another significant challenge is engagement, as ensuring active participation and commitment from both academia and industry stakeholders is vital to the platform's success.

Operational feasibility poses logistical and financial concerns, and it is also important to highlight that EASA’s contribution to managing the initiative is contingent on annual budgetary approvals. With development cost estimates ranging from €130,000 to €290,000 and staffing requirements of 0.5 to 1.5 Full-Time Equivalents (FTEs) on EASA’s side as a minimum. Forming partnerships could help mitigate these costs and enhance the platform's viability.

The main outcome of the ANTFs work in 2024 is a detailed blueprint with recommendations, and a roadmap for implementation through a partnership with SESAR JU in the context of ENGAGE. Guidance on the structure and focus of future academia networking conferences is planned to be developed in

2025 to facilitate knowledge sharing and relationship building between academia, industry, and regulators, while also establishing feedback and reporting mechanisms to ensure continuous improvement.

At his stage the EASA Executive Committee (EXCOM) was involved in the further decision making. At its meeting on 12th August 2024 the EXCOM reviewed the interim progress report of the AN TF and considered the funding options that the group explored, including, as preferred option, synergies with existing mechanisms, in particular entering into a partnership with SESAR JU to expand the established ENGAGE network, currently limited to the field of ATM.

The ExCom discussion focused on the added value for EASA in driving such initiative forward, considering also other ongoing Agency activities related to innovation. Considering the potential to help the Agency in meeting its obligations set by Art. 86, it was agreed to explore cooperation with SESAR JU first at Senior Management level and, if positive, to be further developed in the context of the revised Research & Innovation strategy which is under preparation in Strategies and Safety Management Directorate.

EXCOM agreed to inform the European Commission and seek guidance on advancing the initiative, and to explore a partnership agreement with SESAR JU's ENGAGE project for collaborative operations.

4.4 Recommendations

Following a presentation and discussion at its meeting on the 6thNovember 2024, the SciCom formally agreed in written procedure on a recommendation to establish a partnership between EASA and S3JU under a future ENGAGE program and that the two Scientific Committees should hold a joint meeting in 2025 to further explore a future cooperation with a view to establish an academic networking platform that covers all areas of aviation safety, security and sustainability. This meeting should aim at the development of a paper to be presented at the EASA-SESARJU Management Meeting for Decision.

Based on the outcome of the EXCOM session the following next steps will need to be undertaken:

- Consultation of the Commission
  - Share EASA's conceptual ideas on a partnership between EASA and SJU for an expansion of/cooperation in the context of ENGAGE.
  - Advocate Commission support for broader funding beyond ATM research.
  - If supported, seek guidance on advancing this initiative.
- Engagement with SESAR JU:
  - Explore partnership possibilities for ENGAGE3.
  - Organise a joint SciCom sessions for a consolidated action plan.
  - If agreed by SESAJU and the SESAR JU SciCom analyse how the EASA Blueprint could be aligned or merged with the current ENGAGE mechanism.

Roadmap:

While maintaining a certain degree of flexibility is important, the Academia Networking Task Force will endeavor to adhere to the following milestones:

In 2025, the focus should be to negotiate and enter a partnership with SESAR JU and to develop a joint concept for a new ENGAGE with a wider remit beyond ATM to cover all aviation related safety, sustainability and security topics.

January-February 2025

- Prepare for SESAR JU partnership negotiations:
    - Initiate discussions with SESAR JU leadership and include the ANP initiative as a formal agenda item in their February 19, 2025, Scientific Committee meeting.
    - Draft and circulate materials for alignment ahead of the negotiations.

March-May 2025

- Plan and conduct Joint SCICOM session:
    - Organize a joint SCICOM session, targeting the Airspace World Conference in May 2025 as a venue for detailed discussions and alignment on Engage 3.
    - Develop an agenda to address:
        - Widening the scope of ENGAGE beyond ATM.
        - Integrating the ANP blueprint into the framework.
    - Propose an action plan for the partnership.

April-October 2025

- Further refine the partnership framework:
    - Use feedback from the joint SCICOM session to refine the ENGAGE 3 partnership concept.
    - Begin preparations for the integration of ANP into ENGAGE 3 operations.

October-December 2025

- Develop implementation and transition plan:
    - Finalize the implementation and transition strategy for Engage 3.
    - Prepare for operational alignment with César Joint Undertaking and funding allocation discussions.

2026 Goals

- Host Academia Innovation Conference:
    - Plan and budget for an Academia Innovation Conference in 2026.
- Virtual Academy and Training:
    - Explore opportunities to link the ANP with EASA's Virtual Academy initiative for developing training packages aimed at safety regulators and PhD students.

5 Report of Task Force #2: Impact of climate change

5.1 Introduction and Scope

In its sixth assessment report[1], the Intergovernmental Panel on Climate Change (IPCC) reported that the global mean air surface temperature has increased by 1.1°C in 2020 compared to pre-industrial levels. They also foresee a very likely further increase to 1.5°C before 2040 and 2.0°C before 2060. In addition, regardless of the scenario, temperatures will likely rise in Europe faster than the global average.

This IPCC report states that every incremental increase of the global mean air surface temperature increases the impacts of severe and extreme weather events, such as storms and hurricanes, heatwaves, heavy precipitations, flooding, droughts, etc.

This increasing impact can manifest itself in numerous ways, including:

1. increased magnitude of the severe and extreme weather events;
2. increased frequency of the severe and extreme weather events;
3. severe and extreme weather events occurring in new regions;
4. variability of the occurrences of severe and extreme weather events (for example, occurring either earlier or later in the year than they have in the past); and
5. more frequent combinations of severe and/or extreme weather events.

Hence, climate change affects trends related to hazardous weather phenomena for aviation (e.g., changes to storm patterns, changes to airborne icing conditions, changing wind patterns, changing precipitation, etc.), which may significantly magnify some safety risks and create new ones.

For this reason, since 2023 the European Plan for Aviation Safety (EPAS) includes a strategic priority to manage the impact of climate change on aviation safety[2], and since 2024 a research action to review scientific works on the past and future trends regarding weather-related hazards for commercial air transport aeroplanes, and on the impact of climate change on these trends[3]. For future trends, the interest is on the projected changes associated with different emission scenarios from the IPCC. The typical economical lifecycle of large aeroplanes and associated ground infrastructure and ground communication, navigation and surveillance systems puts the major focus on changes until the middle of the century.

More specifically, EASA expressed an interest in investigating the trends regarding these potential hazards and safety risks:

- Severe turbulence (within cloud and in clear air) during climb, cruise and descent,
- Hail during the flight,
- Lightning strike during the flight,

[1] Refer to Assessment report 6 (Climate Change 2021, the physical science basis), August 2021.
[2] Refer to EPAS 2023-2025 Volume I, Strategic priorities (European Plan for Aviation Safety (EPAS) 2023-2025 | EASA (europa.eu)), section 3.1.1.
[3] Refer to EPAS 2023-2025 Volume II, EPAS actions, 2024 edition (European Plan for Aviation Safety (EPAS) 2023-2025 | EASA (europa.eu)), research action RES.0059.

- Wind hazards associated with severe convective weather (e.g. low-level windshear during approach, take-off or initial climb, updrafts, tornado, etc).
- Contaminated or flooded runway and fog during landing,
- Severe airborne icing during the flight,
- Sand and dust damage during the flight,
- Mass diversion of flights caused by a large-scale weather event,
- Surface weather conditions affecting take-off safety, and
- Bird strike during take-off or landing.

The Task Force #2 was formed in the SC meeting in March 2022. In 2022, it consisted of three scientific members (Vincent-Henri Peuch, Christiane Schmidt, and Nicole Viola) and two EASA members (Guillaume Aigoin, Senior Officer – Strategic Programmes, and Filippos Tymvios, Meteorology Expert); in 2023, it consisted of two scientific members (Christiane Schmidt and Nicole Viola) and two EASA staff members (Guillaume Aigoin and Filippos Tymvios), as well as a temporary scientific member (Suzanne Salles, PhD student); in 2024, it consisted of three scientific members (Silas Michaelides, Christiane Schmidt, and Nicole Viola) and two EASA staff members (Guillaume Aigoin, and Amela Jeričević, Meteorology Expert).

Task Force #2 deliverables are an important information source for EASA activities to manage the impact of climate change on aviation safety (such as the European Network on Impact of Climate Change on Aviation[4]) and for the European Safety Risk Management process[5].

5.2 Work Plan and Methodology

Since 2022, the Task Force has investigated a selected number of hazards, namely severe convective storms and hail, clear air turbulence, sand and dust damage during flight, airborne icing, rising air temperatures and their effects on take-off performance, coastal flooding, heavy/extreme precipitation, and jet streams and their effects on weather patterns. In addition, a preliminary analysis of lightning was performed.

The scientific members of the Task Force have reviewed the state-of-the-art knowledge (review of more than 400 scientific papers) of the chosen hazards and deepened open issues with international experts in the fields, namely in 2022: Prof. Michael Kunz, Dr. Susanna Mohr (both from the Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Germany) and Dr. Timothy Raupach (Climate Change Research Centre, University of New South Wales, Australia) for hail, John T. Allen (Associate Professor of Meteorology, Central Michigan University, USA) for hail and severe convective storms, and Paul Williams (Professor of Atmospheric Science, University of Reading, UK) and CERFACS, Laurent Terray (Director of the Climate modeling and Global change (GLOBC) Team at CERFACS and PhD Students of the GLOBC Team at CERFACS) for clear air turbulence. In 2023: again with Paul Williams and CERFACS (Christian Pagé and Mohamed Foudad), moreover, with Pieter Groenemeijer and Francesco Battaglioli (both from the European Severe Storms Laboratory) on hail and convective storms, and with Victor Gensini (from the Northern Illinois University, USA) on

[4] Refer to EASA launches new initiative to tackle impact of climate change on flight safety | EASA (europa.eu)
[5] Refer to Safety Risk Management | EASA (europa.eu)

dynamical downscaling. In 2024: Dr. Edmund Meredith and Prof. Uwe Ulbrich (both from the working group Climate Diagnostics and Meteorological Extreme Events at FU Berlin).

In 2024, the work of the Task Force was organised as follows:

- Silas Michaelides was responsible for coastal flooding.
- Christiane Schmidt was responsible for heavy/extreme precipitation.
- Nicole Viola was responsible for jet streams and their effects on weather patterns.

Specific virtual meetings were scheduled with these international experts to further discuss their latest findings.

All members of the Task Force, i.e., the scientific members and the EASA members, regularly met through biweekly virtual meetings during which the scientific members presented the progresses of their research. The meetings were also useful to further elaborate together the information of the experts in climate change and to prepare the presentations for the meetings of the EASA Scientific Committee.

5.3 Key Findings made during the period 2022-2024

5.3.1 Severe Convective Storms and Hail

For details of the development of convective weather and associated phenomena, definitions, observations, proxies[6] for projections, projections, as well as knowledge gaps and uncertainties, we refer to the appendix. Most projections are based on proxies, but also projections using dynamical downscaling are reviewed.

Hail.

- Any observational data for hail is sparse.
- For ***Europe***, past trends on hail show little agreement, though a recent analysis indicates a **strong and significant increase in hail frequency in parts of Europe, e.g., in Northern Italy**.
- For ***Europe*** an **increase of the frequency of environments that are favourable for hail** (with low significance and some contradictions, e.g., the UK) **is projected**—even for the middle of the century. For the end of the century and RCP8.5 this includes increases of up to 160%. Changes are attributed to more convective instability because of low-level moisture and an increasing melting level height.
- For ***North America***, past trends do not show clear trends.
- For ***North America***, projections of hail intensity (hail sizes/damaging hail stones) and frequency are consistent between approaches based on different climate models, and an **increase of days favouring severe convective storms within most regions and seasons is projected**. The

[6] For most weather phenomena, the phenomenon itself cannot be projected. Hence, researchers use variables that they can measure/project—so called proxies—to infer information on the actually interesting variable, e.g., the frequency or intensity of hail. For example, for hail, proxies for convective instability, for the microphysical processes and for vertical wind shear are used—and different proxies exist for all of these.

increase in environments is particularly projected for warm seasons and warm and humid regions, the increase in intensity/severity is projected for dry and cool regions, but with fewer events. Altogether a shift to larger hail (on the ground) is projected. The number of studies with projections for the **middle of the century are limited**.

- For ***Oceania***, the only past trends exist for Sydney, with a negative trend for severe hail.
- For ***Oceania***, projections are scarce, but the existing studies agree in trends: **an increase in frequency, severity, and favourable environments**, but also large inter-decadal variability. The only projection for the middle century is for the Sydney Basin, also with an increase in frequency and intensity of hailstorms.

For a detailed description on the existing past- and future-trend studies (results, methods used, considered time frame etc.), please see the appendix.

Knowledge gaps:

- Hardly projections for regions outside of Europe and North America exist, because the same proxies cannot be used for different world regions.
- New proxies must be developed for other regions.
- Observational data are spatially limited.
- Few future-trend studies of the middle of the century exist—not because methods are lacking, but because results for end of century are more statistically significant.
- Data for 500 hPa (about 5000-6000 meters altitude) is lacking.

Uncertainties in the analyses stem from a variety of factors:

- Trigger mechanisms/initiation for hail are not considered in many studies—and even if the atmosphere is prone to produce hail, this still hardly happens.
- The microphysical processes of hail are still associated with high uncertainties.
- Hail events have high variability.
- Proxy-based studies have a low resolution in space and time, while for the actual formation of hail a high resolution is needed, which in turn is very computationally expensive.

For a detailed description of the reasons and consequences of the knowledge gaps and uncertainties, please see the appendix.

Severe Convective Storms (Thunderstorms).

- There do **not exist reliable, long-term records of severe thunderstorms**. The largest set of records exists for the US. However, a recent study indicated that the **occurrences of thunderstorm environments have significantly increased across most of Europe during the past 72 years.**
- For ***Europe***, an **increase in frequency of favourable environments for severe thunderstorms and the number of days with such environmental conditions is projected**—with varying magnitude. However, for **southwestern and southeastern Europe and northwest Ireland, a**

slight decrease in thunderstorms is projected. For certain regions (Iberian Peninsula), the increase is most pronounced in summer and fall. The **cleanest upward trends** can be described for **Southern Germany, Italy and Southern France**. The driving factor for the increases is **that thunderstorms are more likely to produce more severe weather hazards in future climates.**

- For ***North America*****,** an **increase in frequency of favourable environments for severe thunderstorms and the number of days with such environmental conditions is projected** for several regions in the US. For spring and fall and increase of severe thunderstorm environments is already projected before a global warming of 2°C for the Eastern US. The **largest increase** in the number of days with severe thunderstorm environmental conditions is projected for **summer and spring**—with largest increases for **regions close to the Gulf of Mexico and the Atlantic**. An **increase in the frequency and intensity of supercells**[7] is projected for the **eastern contiguous US**, they will be less frequent in parts of the Great Plains. The **season for hazardous convective weather** is projected to become **longer**.
- For ***Oceania*****,** an **increase in severe thunderstorm environments is projected for northern and eastern Australia**, but only a single study exists.
- For ***Japan***, a doubling of the frequency of strong tornadoes is projected for spring and (geographically limited) for summer.
- For the ***world***, a **frequency increase in environments favourable to convective storms of 5-20 percent per °C of global warming is projected.**

For a detailed description on the existing past- and future-trend studies (results, methods used, considered time frame etc.), please see the appendix.

Knowledge gaps/Problems:

1. Projecting the initiation of convective storms is still very imprecise.
2. No good proxies are known for regions not in the USA or in Europe.
3. Few future-trend studies for the middle of the century exist—not because methods are lacking, but because results for end of century are more statistically significant.
4. Existing global climate models and severe convective storms have different scales; hence, many severe storms cannot be detected by the current generation of global climate models.

5. When projections are made for severe convective storms, different phenomena (wind, hail, tornadoes) are aggregated; however, these are not favoured by the same environmental conditions, and considering them as a unified set of hazards is problematic.
6. Environments that are favourable for severe convective storms must not result in a storm, the likelihood for initiation is very local (which is not well reflected in global climate models).

Uncertainties:

[7] intense, long-lived thunderstorms, responsible for most damaging hail and deadly tornadoes

- In climate models, proxies are used to project conditions favourable for severe convective storms—this does not mean that a severe convective storm actually forms.
- Many phenomena have large interannual natural variability and discriminating between climate change and this natural variability is problematic.

For a detailed description of the reasons and consequences of the knowledge gaps and uncertainties, please see the appendix.

Problems 4 and 6 (and in parts the first listed uncertainty) may be overcome by dynamical downscaling: in global climate models, convective processes are parameterized instead of simulating storms directly. Thus, the resolution on severe convective storms is significantly larger than that used in operational weather forecasting. To achieve that granularity even for projections, comparable to high-resolution regional climate models, dynamical downscaling is needed: in areas of interest high resolution is nested with the general low-resolution global climate model. That is, the scale is reduced, but dynamically only in those locations that are of interest for severe convective storms. This approach is detailed in the appendix. However, currently dynamical downscaling is associated with various obstacles, for example the very high computational cost and the very large output data sets. For a detailed description on the concept, existing future-trend studies and current limitations, pleases see the appendix.

Lightning.

The following are preliminary results on lightning: a conclusive literature review was not performed in 2023.Various researchers used lightning as an indicator for the occurrence of severe convective storms, hence, while their main goal was not to project changes in the hazard lightning, these are projections for that hazard. Because of the importance of lightning as a hazard for aviation, these preliminary results are summarized. The researchers considered cloud-to-ground lightning.

- ***Across most of Europe***, the **occurrence of lightning has significantly increased during the past 72 years,** with the largest absolute increase in the Alpine and Caucasus Mountains, and the largest relative increase in Scandinavia. **The increases** appear throughout the year, but **particularly during summer**. Across Russia, a significant decrease in lightning occurred.
- For ***Europe***, an **increase in lightning cases for central and eastern Europe are projected** both for the middle and the end of the century and all different representative concentration pathways, for the end of the century, increases in lightning counts over **the southern Nordic countries, the British Isles and parts of the Atlantic Ocean** are projected (with an increase by a factor of 2.6 over Scandinavia). Decreases of lightning counts are projected over various parts of Europe, except for higher terrain—the projected **lightning increases are strongly correlated with elevation**. **During summer, increases are projected for northern and a decrease in central Europe**—this decrease is accompanied with a reduction in mean cloud ice which **yields fewer lightning strikes/thunderstorm**.
- For ***the US***, the strongest positive lightning trends occurred in the southern States over the past 72 years, significant negative trends were found across the Colorado Plateau and the Great Basin.

For a detailed description of the considered studies, please see the appendix.

5.3.2 Clear air turbulence

An important source of Clear Air Turbulence, CAT, is strong vertical wind shear, which is prevalent within the atmospheric jet streams. The investigation here reported has focused on CAT due to jet streams. Effects due to mountain waves and convection have been disregarded. Please refer to the appendix for more details.

The difficulty of long-term CAT prediction is due in large part to the fact that, from the meteorological perspective, turbulence is a “multi-scale” phenomenon. In the atmosphere, turbulent “eddies” are contained in a spectrum of sizes, from 100s of kilometres down to centimetres. The effect of the turbulence eddies on aircraft acceleration and trajectory are more pronounced when the size of the eddies is about the size of the aircraft. While large scale eddies can be forecasted, small scale eddies cannot. However, it appears that most of the energy associated with turbulent eddies on the aircraft scale cascade down from the larger scales of atmospheric motion. Assuming the large-scale predictions are sufficiently accurate, the turbulence prediction problem is then one of identifying large-scale features that are conducive to the formation of aircraft-scale eddies. Therefore, diagnostic indices from numerical weather prediction models are used to identify and predict regions likely to contain CAT. The diagnostics indices are mathematical models that generally assume that the smaller-scale turbulence is formed as a result of conditions set by the large-scale flow. Then the clear-air turbulence diagnostics are converted into eddy dissipation rates (EDR). The eddy dissipation rate is a natural measure for quantifying the strength of turbulence.

Globally, results of two independent research teams on historical patterns and trends of CAT in the recent four decades (1979–2019/2020) show that high frequencies of MOG CAT occurred on the northern side of the jet in the winter period (DJF) and three maxima patterns were found over the East Asia, Northern Pacific, and North-western Atlantic regions (and continental United States for one research team). There is substantial agreement between these scientists on hotspots for MOG CAT in past trends and on their geographical locations. However, there is no agreement on which is the region most affected by MOG CAT, being East Asia for one team and North Atlantic for the other.

Current results of CAT future trends span typically over 30 years (2050-2080) and reveal that the busiest international airspace around the middle and high latitudes (North Atlantic, North America, North Pacific, Europe, and Asia) experiences larger increases in CAT than the global average, with the frequency of severe CAT approximately doubling at 200 hPa (12 000 m above sea level) over North America (+113%), the North Pacific (+92%), and Europe (+161%). The less congested skies around the tropics (Africa, South America, and Australia) generally experience smaller increases. Whereas globally, it is light turbulence that experiences the largest relative increase, locally, it can be severe turbulence (e.g., over Europe). For each strength category and geographic region, the increase in frequency is larger at 200 hPa than 250 hPa (10 000 m above sea level). The increase in frequency generally displays relatively little seasonality.

The same future trends for CAT is confirmed by various multi-model climate projections, which indicate that the positive trend will continue in the future with the global warming. Results reveal that North Africa, East Asia and Middle East are MOG (Medium or Greater) CAT hotspots with high agreement amongst the climate models and the CAT diagnostics. In general, models project a MOG-CAT increase within the 20-40°N latitudinal band and a weak decrease northward. The projected increases in MOG-CAT frequency over these regions are greater when the global mean air surface temperature is higher. Even though the results of different research teams are consistent in some cases (i.e. the increase of frequency of occurrence of MOG CAT with global warming scenarios for certain hotspots), complete agreement amongst scientists has not been reached yet for all geographical areas and all seasons. Contrary to previous studies, some recent research results show in fact a slight decrease in MOG-CAT frequency over the North Atlantic and a MOG CAT frequency increase over North Africa and Middle East.

Uncertainties mainly relate to:

- **diagnostics**. Most of the uncertainties stems from the turbulence diagnostics rather than the climate models. The limiting factor that is preventing the reduction of uncertainty in projections of future CAT does not lie with climate models, but with CAT diagnostics. Therefore, to reduce these uncertainties, further research is needed to improve and refine the diagnostics. Considering specific set of diagnostics, particularly weighted average of set of diagnostics, instead of simple average, could be an interesting approach to increase accuracy of results. Weighted average allows in fact to make more skilful diagnostics count more. The skill of a diagnostic is considered higher if there is higher agreement with observation data. Weighted linear combinations of the clear-air turbulence diagnostics calculated from numerical weather prediction models have been found to have significant skill when verified against pilot reports (PIREPs), and these combinations are currently being used for operational turbulence forecasting. In addition, gaining further insights into the circumstances in which each individual diagnostic does (and does not) add useful information to the assessment of CAT intensity level could be crucial, so that a diagnostic may be down-weighted or eliminated from the ensemble on those occasions when it is merely adding noise. Reaching these insights will likely require further improvements in our fundamental understanding of the sources and dynamics of CAT. These could lead to consider different set of skilful diagnostic indexes to best represent CAT due to diverse physical phenomena in different geographical areas. This specific
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  issue appears to be extremely challenging. Aircraft measurements may be very useful to push the limits of current research. However, aircraft measurements may not be directly available.
- **Future radiative forcing scenarios**. The future radiative forcing scenarios depend on socioeconomic and political factors. These estimations are of course affected by uncertainties.

Limitations of current analyses mainly relate to:

- the altitude under consideration. In the state-of-the-art literature only 200 hPa and 250 hPa, corresponding to 10 000 and 12 000 m above sea level, have been investigated so far. Investigating lower and higher altitudes to cover a wider range of civil passenger aircraft may be of interest in future analyses. Moreover, the current typical cruise altitudes of medium-large subsonic civil passenger aircraft of 10000 to 12000 m above sea level may also change in the future, depending on the rise of the tropopause and consequently the rise of the jet streams due to an increasingly warming environment, notwithstanding the optimal aircraft performance and the propulsive technology requirements.

- The sources of CAT under consideration. Present results do not generally include all possible sources of CAT but focus mostly on CAT due to jet streams.

5.3.3 Rising Air Temperatures and Effects on Take-Off Performance

According to the IPCC's sixth Assessment report, compared to the pre-industrial period 1850–1900, the average global surface temperature is expected to rise by 1.2 to 3.0°C depending on the socio-economic scenario over the period 2041-2061 and by 1° C to 5.7° C over the period 2080–2100. More details on socio-economic scenarios, future projections and climate models are found in the appendix. Following are the main takeaways of the literature review on the impact of rising air temperature on take-off performance of large airplanes (for more details, please see the appendix):

- The review has shown that according to the cited studies, the intensity and duration of heatwaves linked to climate change have a degrading impact on take-off performance of large airplanes. The overall trends of rising temperatures in past and future periods are translatable in trends of lower performance for aircraft.
- For past trends, studies on some selected airports show a steady and significant decrease of the average MTOW allowed by performance that result from rising temperatures and changes to wind patterns.
- For future trends, projections show an increase in restrictions between reference historical periods and an even sharper increase between mid-century and end of century periods which depend on aircraft, airports and projected socio-economic scenario for the future.
- Studies show that airports most impacted are airports where daily temperatures are high with restrictive conditions like high altitude and short runways being additionally limiting factors. The severity of impact depends on degree of temperature of course but also on the type and weight of aircraft, the dimension of the runway considered and the altitude of the airport.
- Overall, aircraft that seen most impacted by limitations seem to be heavier ones. But it is important to view impact on an aircraft linked to a specific runway in specific atmospheric conditions. A medium-haul aircraft might have degraded performance at high temperatures but if it is operating on a long runway dimensioned for larger aircraft, the impact might not be very important.
- It is important to differentiate cases where the margin for degraded performance is high or not. The length of many runways is such that they still permit take-offs under considerably degraded performance.
- It is important to note even though no restriction must be imposed, the TOD "safety margin" (i.e. the remaining distance to the end of the runway when the aircraft reaches a height of 35 ft according to TOD computation) is reduced with degraded performance...
- Most of the studies reviewed focus on large commercial airplanes, mostly A320 and B737 which are medium-haul aircraft, the main reason for this choice was to make the study's scope as wide as possible so choosing aircraft that are largely used around the world, in many airports under a large range of atmospheric conditions. It seems however that the sensitivity of

performance to temperature gets higher with heavier TOW so the impact on the largest airplane models needs to be studied.

- In most of the studies cited, most airports are located in North America and Asia. Other continents are not well covered.

5.3.4 Dust, dust storms and sand storms

For details on the origin of atmospheric dust, dust storms and sandstorms, the safety risks caused by dust and sand for aviation and a preliminary review of scientific publications regarding future trends, refer to the appendix.

5.3.4.1 Origin and safety effects of dust and sand

Atmospheric dust and sand are caused by a combination of natural and human factors, including wind erosion of dry soils, desertification, land use and climate variability. The cycles of atmospheric dust and sand involve the movement of particles through various processes such as emission, transport, deposition, and re-suspension. Sand particles are larger than dust particles, are not transported far from the source and fall out of the air faster whilst dust particles are smaller in size and therefore can be transported at high altitudes and over very long distances, even crossing oceans.

Dust and sand in the atmosphere can damage aircraft engines, sensors and windshields, lead to failure of communication and navigation equipment on the ground and of meteorological observations equipment, and cause serious health problems among airport and ground handling staff. Dust and sand can also significantly reduce visibility, making VFR operations impossible.

Especially severe or repeated dust storms or sandstorms have adverse safety effects. Such episodes may lead to simultaneous closure of several airports and large numbers of flight cancellations and/or diversions in the regions where they occur.

Besides dust storms and sandstorms, prolonged exposure to higher background concentration of dust may also have adverse long-term effects on airworthiness, serviceability of ground equipment and the health of ground staff. This is more specifically an issue for operations taking place in the Global Dust Belt that spans over parts of North Africa, the Middle East, South Asia and the Southwest part of USA. Higher concentration of dust in the upper troposphere also exist in the so-called Upper Troposphere Dust Belt.

5.3.4.2 Results of research on trends

This preliminary review of research publications found that the safety risk associated to dust and sand-related hazards is increasing due to climate change in many areas of the Global Dust Belt. However, although climate models and projections provide insights into potential changes that could affect dust storms, it's important to note that these projections come with uncertainties, and regional variations on the uncertainties exist.

As the mean air surface temperatures continue to rise, many regions in the world are experiencing more frequent and intense droughts, making the soil more susceptible to wind erosion and so providing extended source areas for atmospheric dust and sand. In addition, climate projections suggest that under all Representative Concentration Pathway (RCP)[8] of the IPCC, the surface soil moisture will further decrease in all regions, except for central Africa, central Asia and Alaska. This

[8] Representative Concentration Pathways (RCPs) are greenhouse gas concentration trajectories until the end of the 21st century that were adopted by the IPCC and are commonly used for modelling future climate trends.

global decrease of the surface soil moisture is projected to be more significant under the RCP scenarios with higher radiative forcing, and to be more pronounced in winter and summer seasons. This is expected to result in increasing the average concentration of atmospheric dust.
In addition, several publications indicate that climate change is likely to increase the frequency and intensity of dust storms in the Global Dust Belt, where they are already common.
It seems that the future trends for dust storms in Europe and the Artic circle have not yet been explicitly researched. However, research work indicates that the conditions for uplift of dust in the Sahara Desert will be more frequently met. In addition, poleward atmospheric flow patterns favourable for the transportation of dust from North Africa to Europe are expected to become more frequent. The enhanced conditions for dust uplift combined with more frequent conditions for dust transport from the Sahara could result in increasing exposure of Europe to atmospheric dust in the future.

5.3.5 Airborne Icing

From a meteorological perspective, initial icing research focused on icing caused by small water droplets up to 40 µm in diameter. Regulations were then introduced in the 1990s, which describes meteorological conditions with potential for in-flight icing with water droplet diameter up to approximately 2 mm, referred to as supercooled large droplet (SLD) icing. Eventually, as far as the ice crystal icing is concerned, knowledge of the underlying physics is currently limited. The following preliminary review has focused on water droplet icing (small water droplets and SLD icing). Ice crystals have been disregarded. Please refer to the appendix for more details.
The analysis of past trends of airborne icing is crucial to accurately predict the future trends and to possibly understand the impact of climate change on this physical phenomenon. Past trends of in-flight icing conditions have been assessed over the entire globe and throughout all seasons through CIP/CIP-sonde (Current Icing Product) method and SIGMA (Meteo France's System of Icing Geographic Identification in Meteorology for Aviation) algorithm. The CIP-sonde method uses a version of CIP that was tailored to determine the potential for icing and SLD using coincident observations from balloon-borne soundings and surface stations. The second method, SIGMA, is an algorithm to assess the potential presence of icing from global-scale model reanalyses of temperature (T) and relative humidity (RH).
In general, in past trends of in-flight icing, the low-to-moderate icing risks in the Northern Hemisphere tend to be most frequent in a zonal band poleward of about 40°N latitude, with broad extensions to lower latitudes at different longitudes. These geographical areas of icing risks stretching to southern regions are more significant in January, when the polar jet stream is strong and there is a sharper boundary between polar and mid-latitude air masses, then weaken slightly in April and finally become almost non-existent in July, when the regions with higher risk of icing tend to be confined to the Arctic. As the Arctic quickly cools in the fall, these meridional extensions are reestablished by October. In the tropics, a high-altitude weak icing belt is generally found within 20° of the equator and moves across latitudes throughout the year. In the Southern Hemisphere, icing risks is wide spread longitudinally and most common between 50° and 70°–80°S of latitude, with the southern limit along the coast of Antarctica. Elevated icing frequencies are semipermanent, but maximized in July, the peak of winter there.
Analyses of past trends over about 40 years (1979-2020) of airborne icing show that the frequencies of icing risks at the same altitude decrease when moving from weak to severe risk. Results reveal the

seasonality of the airborne icing phenomenon, being the highest frequencies of icing risks at lower altitudes in winter season and at higher altitudes in summer season.
To better understand the impact of climate change on airborne icing, research studies have been carried out to compare the past trends with the future trends of seasonal frequencies of icing risk. Past trends have been based on ERA5 reanalysis data over the time period 1979-2014, whereas future trends have been based on the CNRM-CM6-1 climate model considering Global Warming Level equal to +4°C (SSP 585). For different altitudes the frequency of weak icing risk increases from past to future trends, being more significant at higher than lower altitudes. Even though the weak risk of in-flight icing cannot be considered as weather hazard, its increase of frequency from past to future trends appears still relevant and requires further analyses. The hazard magnitude shall be investigated more deeply as currently publicly available research results do not cover the entire spectrum from weak to severe icing risks. This holds true both for past and future trends of airborne icing. Therefore, nothing can be inferred on the evolution of intensity and duration of airborne icing as weather hazard. As far as the geographical coverage is concerned, global coverage seems not to be met yet for future trends of airborne icing, both in terms of longitudes and latitudes.
Uncertainties mainly relate to:

- models and algorithms to predict icing conditions. Models/algorithms, like CIP/CIP-sonde method and SIGMA algorithm, do have uncertainties that affect their accuracy and that depend on the implemented approach and methodology. In particular:
    - the CIP method has been developed as a multiple data source, hybrid approach to the diagnosis of icing. It combines satellite, radar, surface, and lightning observations with numerical model output and PIREPs to create an hourly, 3D diagnosis of icing and SLD. CIP-sonde similarly examines the vertical structure of the atmosphere using coincident
    - observations from soundings and surface stations. Based on this information, each profile is described by one of several icing scenarios (e.g., classical freezing rain). Within each scenario, fuzzy logic membership functions are applied to the data and then the potential for icing (small water droplets icing and SLD icing) is determined at each level.
    - The SIGMA algorithm requires only grids of T and RH, which can be derived from reanalyses data of the atmosphere, created using observations from soundings, surface stations, and satellites (among others). The operational version of SIGMA combines model forecasts of temperature, T, relative humidity, RH, and vertical velocity with real-time observations of cloud and precipitation characteristics from satellite and radar.
- The climate models used to analyse future trends of in-flight icing. Current research works are assessing the accuracy and performance of climate models in predicting icing conditions compared to ERA5 reanalysis data.
- Future emissions of greenhouse gases depend on socioeconomic and political factors.

Limitations of current investigations are listed hereafter:

- Generally, the techniques/models/algorithms, like SIGMA and CIP-sonde, do not take deep convection into account. This is done because aircraft specifically avoid flight into thunderstorms because of the many hazards they present, such as hail and lightning. Thus, their inclusion would extend the areas of potential exposure to in-flight icing. This choice is likely to result in underestimating actual icing frequencies in areas prone to thunderstorms, especially at relatively high altitudes.

- Current models/algorithms do not include the impact of aerosols on ice formation but research activities reveal that there is a relationship between aerosols and super-cooled water droplets. It seems that super-cooled water form more when there are less aerosols but this requires further investigations.
- Analyses of future trends of airborne icing should extend to higher altitudes that correspond to the typical cruise altitudes of large aeroplanes and include ice crystal icing, which are rarely considered in present investigations.
- Analyses of future trends of airborne icing should cover the entire globe at all latitudes.

5.3.6 Coastal Flooding

An analysis of the impacts of climate change on coastal flooding risk and its effects on aviation safety is given in Appendix F. This analysis provides, firstly, an insight into the recent past trends in sea level rise, and, secondly, it reviews the available projections of coastal flooding as a result of climate change. The key findings from a survey of the published literature on this issue are provided in this section.

One of the direct consequences of global warming is the widespread and rapid shrinking of the frozen part of the Earth's climatic system. The current change is manifested with the melting of several forms of ice, including a massive and extensive retreat of the planet's glaciers and ice sheets, a decline of the extent of the sea ice and snow cover and a degradation of the permafrost. Although the global sea level rise is primarily ascribed to the melting of the ice contained in the glaciers, ice sheets, sea ice and thawing of permafrost, other factors are also identified to contribute to the recent past, present and foreseen sea level change, such as ocean thermal expansion leading to increased ocean volume.

The rising global sea level due to climate change is considered as the major factor leading to increased risks of coastal flooding. However, coastal flooding can be the result of several other factors and an understanding of these provides a clearer picture of this hazard and its consequences. In this respect, in addition to mean sea level rise due to climate change, storm surges, astronomical tides, increased frequency and intensity of storms, changes in storm tracks, and river discharge must be taken into account. The interactions between these factors, although difficult to contemplate in the full extent, must also be considered. For example, a storm surge can block or slow down the precipitation drainage into the sea, enhancing coastal flooding, thus augmenting the direct effects of the storm surge. Added to this complex scenery, geographical or geological factors must be given serious consideration in the risk estimation of coastal flooding. In this respect, one of such factors is the postglacial land uplift which in some parts of the European continent is significant, thus counterbalancing the rising sea levels (e.g., the Finish coasts in the Baltic Sea, where land still rises from the sea, following the latest Ice Age); on the contrary, the postglacial sinking of other parts of European coasts is expected to enhance the impact of sea level rise on coastal flooding (e.g., The Netherlands).

It is an undisputed fact that global sea level exhibits an upward trend. Measurements in the 20th and 21st centuries confirm the rise of the global sea level, with the latest consensus on recorded sea level rise due to climate change reflected in the recent Sixth Assessment Report of the International Panel on Climate Change (IPCC). Indeed, the average rate of sea level rise was 1.3 mm per year between 1901 and 1971, increased to 1.9 mm per year between 1971 and 2006, and further increased to 3.7 mm per year between 2006 and 2018.

This upward trend in sea level increase is expected to continue into the current and next centuries, both due to the projected continuance of climate change, but also because the thermal expansion of ocean waters and the melting of land-based ice will continue for several centuries even after a stabilization of surface air temperature.

The climate projections that are used to estimate future sea levels are based on selected climate change scenarios. These scenarios have mostly been adopted as a result of the work presented within the framework of the IPCC. It is worth noting that these scenarios have evolved in the last 25 years, and part of the difficulties in the comparison of research results based on these is due to the different frameworks on which these scenarios are founded. Also, the assessment of future climate change impacts on coastal inundation faces many challenges, primarily due to the large uncertainty in sea level rise projections in the second half of the twenty-first century, and even more uncertain projections beyond 2100.

For the protection and resilience of European airport capacity, it is crucial that airport operators are aware of the risks they face from coastal flooding due to climate change and understand the steps they should take to better plan well ahead in mitigating these risks at the local, regional, and European level. Bearing in mind the estimated duration for which one can reasonably expect an airport to remain functional, generate income or provide other benefits, the discussion is limited to the climatic projections that are justified by the projected life of an airport infrastructure. Mid-century expected values (year 2050) are related to the expected useful life threshold of existing infrastructure, whereas, end-of-century (year 2100) are related to the expected useful life threshold of currently or near-future planned infrastructure.

The main expected impacts of coastal flooding can be compiled into the following: permanent or temporary loss of airport capacity and airport infrastructure, permanent or temporary loss of ground access to airports, economic costs of sea-level and storm surge protection, delay and perturbation from runway inundation, network disruption, and impacts on en-route capacity due to lack of ground capacity.

There is not an absolute agreement as to the extent of the risk of coastal flooding on European aviation. This is primarily because different researchers have made use of different climate change scenarios, models and assumptions. One published study made use of projected sea level rise throughout the 21st century and estimated that a total of 124 airports in Europe will be at risk from coastal flooding by 2030; in the same study, the number of airports Europe at risk is estimated to increase to 196 by 2080. The findings of another study indicate that 178 out of 273 coastal and low-lying airports in Europe are at risk of coastal flooding by 2090. Recent findings from a third investigation indicate that as many as 90 airports at a European level are at risk under a 2◦C temperature rise scenario, increasing to 110 under an extremely worst-case scenario. The list of airports at risk includes some major airports in Europe.

In spite of the above differences in the estimation of the extent of the impact of coastal flooding on European aviation, the published risk projections converge on one point, namely, that the risk of coastal flooding and its impacts on European aviation can be considerable. Bearing in mind that IPCC has recently published a set of more advanced climate change scenarios, it is important to make use of these updated versions and undertake a more concerted effort in establishing the extent of the impact of coastal flooding risk on European aviation.

Based on the most recently established climate change scenarios and other datasets, a number of useful tools have been developed which can offer valuable assistance in the effort for compiling a local, regional and pan-European assessment of the consequences of coastal flooding induced by climate change on European aviation. Using such tools, simulations based on different climatic scenarios and other conditions can be performed very easily for different regions and particular airports. Selected examples of the usage of these tools are presented in Appendix F for specific regions and airports.

5.3.7 Heavy/Extreme Precipitation

For details on the formation of precipitation, the definition of heavy and extreme precipitation, the measurement of heavy/extreme precipitation and its changes, observations, projections, as well as knowledge gaps and uncertainties, we refer to the appendix. Most projections employ dynamical downscaling, and we refer the reader to Appendix A, section A.4.1 for a discussion of this technique. In 2024, we focused on a **review of the results for Europe.**

- Per 1°K of warming, the water-holding capacity of the air increases by ca. 7% (Clausius-Clapeyron (CC) relation). This yields more water vapor in the atmosphere. Hence, storms can produce heavier precipitation events. Apart from this thermodynamic influence, also dynamic changes (e.g., changes in atmospheric motion) impact changes in heavy/extreme precipitation. Consequently, the scaling rates between extreme-precipitation events and temperature depend strongly on region, temperature, considered rarity of the precipitation event, and even on the season. Thus, the occurrence of extreme-precipitation events can increase with a rate below-the CC scaling rate, at the same rate, or above the CC scaling rate (that is, below 7%/°K, at 7%/°K, and above 7%/°K, respectively).
- Observational data is either based on stations (cover long periods, but only local data and bias from wind etc.) or on satellite or radar images (no longer historical records, but also for remote areas, not only locally). High-quality observational data, particularly for extremes, is lacking.
- For Europe, past trends show strong agreement: in the large majority of stations/observations, extreme (sub-daily) precipitation changed with temperatures; this change in total extreme precipitation is a combination of increases in both intensity and frequency, but dominated by changes in frequency. The relative increase in frequency is higher the more intense the rain-fall event is (that is, for an extreme-precipitation event that occurs every year the relative increase is larger than for a less rare extreme-precipitation event that occurs every month).
- Globally, for short-duration precipitation events (e.g., sub-daily extreme precipitation) a shift to more intense storms and fewer weak storms is likely as temperatures increase. Over most of the mid-latitude landmasses (to which most of Europe belong) extreme precipitation events will very likely be more intense and more frequent.

- For Europe, increases of (sub-daily) precipitation extremes are projected over most of Europe (both for the middle and the end of the 21st century, with larger relative increases for the latter). Thus, there is a projected increased frequency of episodes exceeding higher thresholds. Exceptions, e.g.: large part of the Iberian Peninsula, with projected significant reduction in extreme precipitation in all seasons except for winter.
- Projected scaling rates are higher for short-duration precipitation extremes than for long-duration extremes (i.e., spanning over several days).
- As in the observations, the relative increase in frequency is higher the more intense the rain-fall event is.
- Particularly for high-emission future scenarios, in a changing climate, much higher probabilities of record-shattering precipitation are projected.
- Both the observed and projected increases for extreme precipitation occur even in regions in which mean precipitation decreases/is projected to decrease.

For a detailed description of the existing past- and future-trend studies (results, methods used, considered time frame etc.), please see the appendix.

Knowledge gaps:

- High-quality observational data is needed, in particular, for (short-term) extreme precipitation, as data for this is much sparser than for mean precipitation. Moreover, certain regions of the world are not well covered in the global observation data sets. Observational data should both cover a large region (for gridded data) and a long time period.
- Ensembles of models scaled down to a resolution of a few kilometers—such that convection can be explicitly simulated (instead of using parameters/proxies to simulate its occurrence)—run over long time periods would yield clearer statements than what is currently possible. Running these high-resolution models for longer time periods is currently computationally expensive. EURO-CORDEX, the coordinated downscaling experiment for the European domain9, is a first attempt for such a model ensemble.
- An improved understanding of the interaction of the thermodynamic effect (CC relation) with the dynamic circulation would help to understand better how global warming impacts precipitation events.
- Consensus on the best definition of extreme precipitation (see Appendix G, Section G.2.2 for a discussion of the used definitions).

Uncertainties in the analyses stem from a variety of factors:

- Bias/uncertainty from models.
    - If low-resolution models are used, the used parameterization (see explanation of parameters and proxies in Subsection 5.3.1) leads to precipitation being triggered too often in the model compared to reality, which then produces too light precipitation over a too long period.

[9] https://www.euro-cordex.net/

    - Dynamics yield model uncertainty: El Niño etc. can change with climate change, but the changes can be different in different models.
    - Different models may yield different projections. This holds particularly for projections for summer: in winter, precipitation is mostly forced by large-scale systems, in summer, convection is more important.

- Uncertainties related to the representative concentration pathways (RCPs) used for the simulations.

For a detailed description of the reasons and consequences of the knowledge gaps and uncertainties, please see the appendix.

5.3.8 Jet streams and their impacts on weather patterns

For details on the changes to jet streams and their impacts on weather patterns, please refer to Appendix H.

Jet streams are narrow currents of strong winds that generally blow from west to east across the Earth (zonal flow) and less frequently from northern to southern directions and vice versa (meridional flow). They are located close to the tropopause and are generated by strong temperature gradients between air masses with different characteristics. The most common jet streams are found in the cold air-mass adjacent to the polar and the mid-latitude zones (polar Jet) and the mid-latitude and tropical zones (sub-tropical Jet). In the absence of surface asymmetries and large-scale instability, the jets would uniformly encircle the globe, but regional features such as continents, mountain ranges, and patterns of ocean temperatures act to shape the regional jet streams by forcing north-south wave patterns known as Rossby waves (or planetary waves). Rossby waves manifest as trains of alternating weather patterns of low pressure and high pressure, generally arranged in a line from west to east. Surface air pressure patterns, like the Arctic Oscillation (AO) and the North Atlantic Oscillation (NAO), do also have a mutual influence on the jet streams.

Jet streams vary in terms of position and strength. The effects of natural variability and climate change on jet streams are still debatable. The variability of jet streams and associated Rossby waves play a critical role in our weather and climate. Extreme weather events, such as heatwaves, cold spells, and stormy periods, appear to be more likely when high-amplitude Rossby waves are observed. As large waves tend to progress eastward more slowly, this can cause weather regimes to stall and create persistent weather conditions that may lead to extreme events.

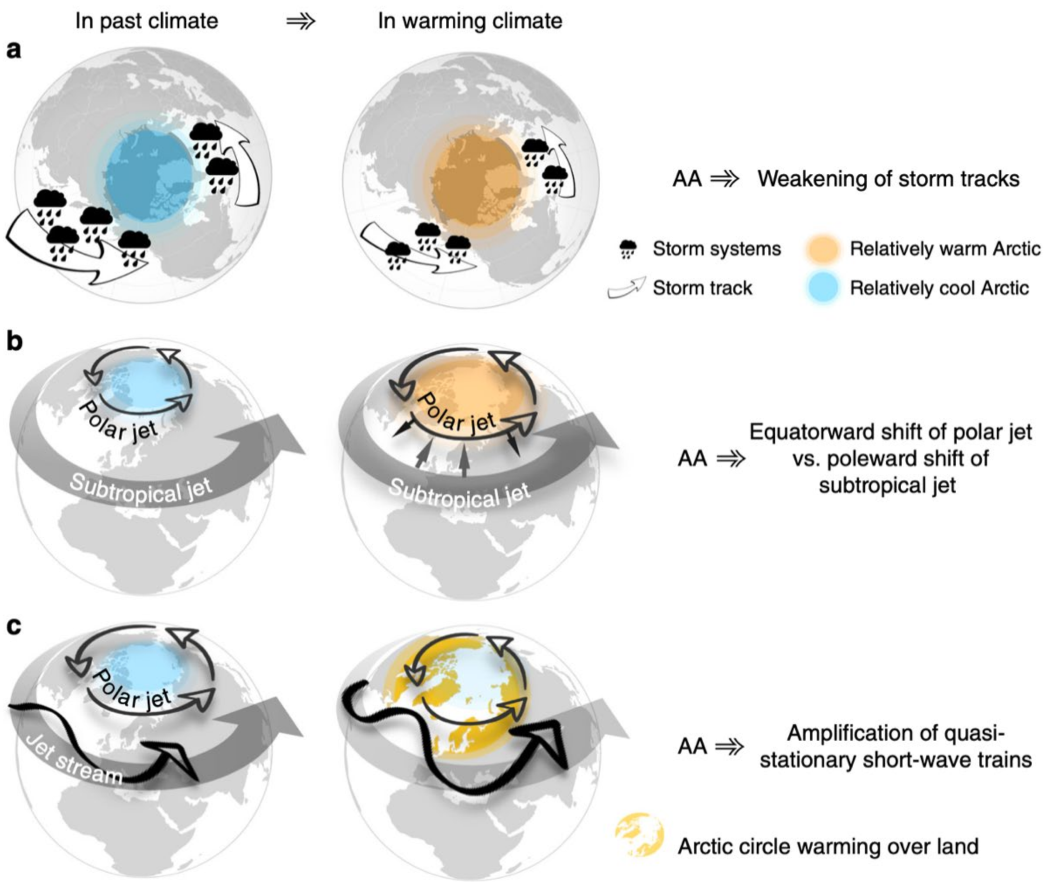

Figure 5-1: Schematic representation of proposed dynamical mechanisms in summer and in warming climates (future projections): a) Weakening of storm tracks, b) latitudinal-shift in jet positions, and c) amplification of quasi-stationary waves

As the north/south temperature gradient is the primary driver of jet stream winds, with a strong gradient fueling a strongly sheared jet, anything that affects the strength of the gradient also influences the jet stream. In recent decades, the Arctic has warmed at a far greater pace than mid-latitude regions. This phenomenon, known as Arctic amplification, has reduced the north/south temperature gradient in the lower atmosphere in past trends.

Future projections also show that in warming climates the Arctic amplification will reduce the north/south temperature gradient at lower altitudes with three main effects: the weakening of the storm tracks, the shift of the position of the jet streams northward and the amplification of Rossby waves (see Figure 5-1), leading generally to weaker and wavier jet streams and consequently more extreme and persistent weather patterns. Conversely, at higher altitudes (i.e., at the top of the troposphere) future projections reveal an opposite trend for the north/south temperature gradient, which will increase instead, as a consequence of the mechanism known as "Tropical upper-tropospheric warming hot spot" (see Appendix H for more details).

The uncertainties associated with these mechanisms and with their effects on weather conditions are admittedly large. Nevertheless, most scientific publications agree on storm track's weakening, as well as quasi-stationary short-wave trains' amplification, which both lead to persistent and therefore extreme weather in the mid-latitudes.

Several studies suggest that the Northern Hemisphere summer weather is already becoming more persistent.

Looking at past trends, over the mid-latitude band (35–60° N) the probability that a warm period persists for one more day increases for longer events, thus, the more persistent a period is, the more likely it is that it lasts even longer. In the mid-latitudes, 80% of all warm periods are shorter than a week and 6% exceed two weeks.

Looking at future projections, for dry–warm persistence results reveal a relative increase in exceedance probability of two-week-long periods of 4% in a 2°C world for the Northern Hemisphere relative to the 2006–2015 data. Rain persistence increases significantly in almost all mid-latitude regions in the Northern Hemisphere, with long periods increasing most. The average likelihood of week-long rainy conditions increases by 26% in a 2 °C world compared to the present. This increase in rain persistence is especially pronounced for northern Eurasia.

The impact of the evolution of jet streams on weather patterns is summarized in terms of hazard seasonality, magnitude, geographical and time coverage, and uncertainties:

- the seasonality of the hazard. Extreme and persistent weather patterns are more likely to occur in summer than winter seasons. Differences between winter and summer due to warmer climates are significant. The same effects are expected to occur in future projections.
- the hazard magnitude (intensity and duration/persistence): averaged over the mid-latitude land area and specifically in ENA (East North America), CEU (Central Europe), NEU (North Europe) and NAS (North Asia), dry, rain and warm periods are all projected to be more persistent in a 2°C world for the Northern Hemisphere. Rain persistence increases significantly in almost all mid-latitude regions, with long periods increasing most. Most of the projected increases in persistence could be avoided by limiting warming to 1.5°C.
- The geographical coverage of the hazard. Most of current scientific publications focus on the Northern Hemisphere.
- The time coverage of the hazard. Investigations focus on mid of the century (2050) as well as end of the century (2100).
- Uncertainties. The uncertainties of the impact on weather patterns due to the evolution of jet streams are significant and are mainly due to the uncertainties regarding the changes of the jet streams themselves. The evolution of the jet streams may depend both on natural variability and climate change and it is mainly related to two competing mechanisms, i.e. , the tropical upper-tropospheric warming hot spot and the Arctic amplification, whose effects are still debatable. The uncertainty of the models' results is also critical. The inter-model spread is not negligible and it is attributable to different simplifying parameterizations employed by state-of-the-art climate models and those can, in a complex, non-linear system, lead to very different outcomes. Some of these discrepancies appear to be caused by different responses in the Pacific and Atlantic regions, seasonal differences in the response, the use of different diagnostics and metrics, and/or biases in models and differences in experimental design.

5.4 Recommendations

Several recommendations are identified for the climate-related trends considered by the Task Force. For a more detailed analysis of these recommendations, please refer to the Appendices A to H.

5.4.1 Severe Convective Storms and Hail

For hail, to the best of our knowledge, studies on hail aloft (HALO) do not exist although they would be very interesting for aviation. Most studies focus on surface hail (because this is interesting both for agriculture and property on the ground), while the major impact on aircraft happens during flight. Hail that may appear on flight level may have melted until it reaches the ground. Thus, based on surface-hail studies, both the frequency of hail encounters and the characteristics of hail aloft (e.g., hailstone size, water content per cubic meter) could be underestimated. John T. Allen specifically highlighted the need for EASA to take action if they would like researchers to specifically study trends regarding HALO. Pieter Groenemeijer emphasized that microwave observation data from satellites could give more information on altitudes for HALO.

Hence, if EASA considers a better understanding of HALO trends—at altitudes relevant for aviation—to be important, we recommend that EASA investigates how to get research teams to work on this specific topic.

Moreover, to close the spatial gaps in future studies, proxies for world regions other than Europe and North America need to be studied. Finally, reducing any of the uncertainties could lead to improved projections.

One of the major problems for convective storms (smaller temporal and spatial scale than current climate models) can be either overcome by a new generation of climate models, or, by—according to interviewed experts—dynamical downscaling. The study of research using this technique (part of which should be published soon) might give more insight. Victor Gensini highlighted that global climate models are unable to simulate perils impacting humans, while dynamical downscaling is able to do so. Moreover, Francesco Battaglioli and Pieter Groenemejier estimated that dynamical downscaling could help to project which type of storm (i.e., isolated storms, long lines of storms, with high tops) will occur—which could be very interesting for aviation. Hence, if EASA considers these points of interest, we recommend that EASA investigates how to get research teams to work on this specific topic. Most studies using dynamical downscaling are performed in and for North America. Hence, if EASA is interested in studies using dynamical downscaling for Europe, we recommend to communicate this to the scientific community and all relevant research programs (such that researchers can obtain funding for the computationally expensive studies).

Both for convective storms in general and for hail specifically, the number of future-trend studies for the middle of the 21st century is limited. The main reason is that statistically significant results can be easier to obtain for the end of the century. However, the economic lifecycles of large aeroplanes (about 30 years) and of infrastructure and ground systems that support large aeroplanes operations make results for the middle of the 21st century more relevant for decisions by EASA and aviation stakeholders than results for the end of the century.

Hence, if EASA considers that an assessment of future trends for the middle of the 21st century is needed by aviation stakeholders, we recommend that EASA communicates this to the scientific community and to all relevant research programs.

5.4.2 Clear Air Turbulence

As far as CAT is concerned, the results of several research team agree on historical trends of increasing MOG CAT frequency over East Asia, Northern Pacific and Northern Atlantic. They also agree that overall, the frequency of MOG CAT will continue to increase, but specific disagreement remains on the most affected regions and on the magnitude of the changes. Uncertainties and limitations in present analyses prevent from reaching accurate predictions in the long-term trends.

Hence, we recommend to further investigate the individual turbulence diagnostic indices and CAT intensity level, and to explore the use of weighted average of set of diagnostics, which may need to be calibrated for the specific conditions of different geographical area. In addition to diagnostics, different forcing scenarios, other than the RCP8.5, should be considered and results should be compared. Moreover, while it seems that climate models play a less significant role regarding the uncertainty in CAT than diagnostic indices, using the new generation of CMIP6 models could bring more accurate results. Eventually, we recommend extending the range of altitudes under consideration below 10000 m and above 12000 m.

5.4.3 Rising Air Temperatures and Effects on Take-Off Performance

- In light of the cited studies, there is a need for focusing case studies on other parts of the world than North America and East Asia. It would be beneficial to the European aviation sector to get focused studies on European region as well as oversea territories of EU member states, especially those already located in warmer climates, or on islands where it might be difficult to extend the runway: French Caribbean, French Guyana, Reunion Island, Madeira, Canaries Islands, etc. Some of these airports are essential to bring commodities to those who live on such territories.
- As shown in the review, assessing impact with a performance model allows more flexibility in the choice of input parameters and sensitivity analysis. For methodologies using an aircraft performance model, it is possible to easily consider different kinds of technologies (provided you find the data needed) and therefore quantify the sensitivity of each to high temperatures. More than assessing the impact rising temperatures due to climate change have on current aircraft, it could inform the conception of future aircraft more resilient in a context of adaptation to climate change. It is important to study the sensitivity of aircraft and propulsion technologies to high temperatures as such conditions will become inevitably more frequent.
- The use of performance models of aircraft in academic research studies is faced with one challenge: access to data for validation of performance models. These models are based on many assumptions and simplifications of mechanical equations and their results need to be confronted with real performance data in order to be validated. Unfortunately, performance data are sensitive and difficult to obtain from either manufacturers or operators.
- When analysing the impact of future temperatures, a high time resolution might allow to quantify more into detail the daily impact on operations. The exceeding of a temperature threshold for take-off performance might not have the same impact on the daily organisation of operations if the threshold is only exceeded for a short or long time slot.
- Quantifying the effect of surface winds together with temperature would be interesting on a safety level for crosswinds and on a performance level for headwinds.

- On a safety level, attention needs to be given to the reduction in safety margins that can be caused by extreme temperatures. In particular, when adding other factors for insufficient take-off performance, like a too low pitch angle or an error in the estimation of take-off weight (TOW). For example, the sensitivity of the take-off performance to a range of TOW error should be quantified under different temperature conditions.

5.4.4 Dust, Dust Storms and Sand Storms

According to this preliminary review of research publications, the studies on historical trends of background dust concentration levels and on historical trends of dust and sandstorms seem to be rather seldom, limited to some geographical regions and to only give general trends. It would be beneficial to establish a complete and more detailed picture of these historical trends, especially for the European region and the surrounding regions (Northern Atlantic, North Africa, Middle East).

It seems that research on future trends could further investigate the effects of long-term changes to the general atmospheric circulation caused by climate change on the transportation of dust. Research on future trends could also investigate possible changes to the characteristics of the Global Dust Belt and of the Upper Troposphere Dust Belt, and the possible consequences of such changes in terms of dust storms and sandstorms, and of background dust concentration levels.

This preliminary review has not looked into the use of climate models in the research works on future dust and sand trends. This aspect would deserve further investigation.

Finally, works on future dust and sand trends should include projections for the middle of the 21st century, as this time horizon is probably more relevant for decisions by EASA and aviation stakeholders than results for the end of the century.

5.4.5 Airborne Icing

For airborne icing, to the best of our knowledge, the analysis of future trends of icing risks, considering the impact of climate change, is still limited from different perspectives: the hazard magnitude and frequency, the geographical coverage, the range of altitudes and the potential sources of in-flight icing. The magnitude of airborne icing in future trends shall be investigated more deeply as currently publicly available research results do not cover the entire spectrum from weak to severe icing risks. This holds true both for past and future trends of airborne icing. Therefore, nothing can be inferred on the evolution of intensity and duration of airborne icing as weather hazard due to climate change. Future trends of airborne icing shall also cover the entire globe at all latitudes and longitudes and analyses shall extend to higher altitudes that correspond to the typical cruise altitudes of large airplanes and include ice crystal icing, which are rarely considered in present investigations. Eventually, as current models and algorithms to predict icing risks do not include the impact of aerosols on ice formation, we recommend to consider this effect as research activities reveal that there is a relationship between aerosols and super-cooled water droplets.

5.4.6 Coastal Flooding

The rising of sea level due to climate change in the recent past is an undisputed fact. Projections on the future trends do not agree quantitatively, but they all consistently show that this trend will continue in the near future, despite the uncertainties. A number of other contributing factors, also resulting from climate change, such as changes in the frequency and intensity of storms, as well as changes in storm tracks, exacerbate the risk of coastal flooding. Coastal and low lying airports in Europe are at an increasing risk of flooding, a risk that must not be overlooked, both in the planning of new infrastructures and for maintaining existing infrastructures operative.

Airports are critical integral parts of our modern transportation infrastructure that are essential to linking people and businesses around the world. Therefore, the flooding of major coastal airports can have a significant economic impact. However, coastal flooding can also affect smaller regional airports, and especially those at small remote islands with limited alternative transportation solutions should be considered as critical infrastructure. As airports are essential service providers to a wide range of stakeholders and users, the airport infrastructures and operations should have high levels of reliability, availability and resilience.

For European airports to remain functional, generate income or provide other benefits, the proposed investigations should reflect on the projected life of existing and new airport infrastructure. In particular, the mid-century (year 2050) expected risk should be related to the threshold of the useful life of existing infrastructure, whereas the end-of-century (year 2100) expected risk should be related to the expected useful life threshold of currently or near-future planned infrastructure.

As the increasing risks for low-lying coastal airports associated with climate change-induced coastal flooding are recognized, it is critical that individual States and the European Union enhance the strengthening of resilience to this hazard. In climate-change risk-management strategies for Europe, the impact of coastal flooding on airports should be considered, as well as the preservation of asset investments. In this respect, lessons learnt from other parts of the World that are also looking to protect their vital airport infrastructure from coastal flooding could foster the formulation of a general framework; however, such a framework must be founded on the particular conditions or those of the individual State. Any European integrated strategy for mitigation and adaptation in response to the impact of coastal flooding in Europe should include coastal airports.

However, there is no single solution for resolving each airport's coastal flooding threat, as each situation is context-specific and must be assessed on its own merits. Indeed, the drafting of a risk assessment plan should be airport-specific, preferably as part of a national plan. Such a plan focusing on individual airports should contain guidelines on factors to be considered in estimating the risk, for example proximity to coast and elevation above mean sea level, as well as identification of any other components of coastal flooding and the possibility of their interactions.

The analysis presented in the Appendix F has revealed that the coastal flooding risk for European airports is not sufficiently documented. Since some of the deficiencies are due to the differences inherited from the use of different climate projections, models and approaches, a uniform and comprehensive investigation is recommended, adopting the latest available climatic information, climate projections and evolving methodologies. Regarding the recommended use of updated climate scenarios, it is proposed to make use of the recent IPCC climatic projections in establishing a coastal flooding risk map for the airports in Europe. Ideally, the estimated risk should be presented in probabilistic terms, thus allowing the users to prioritise actions.

Lastly, it would be useful to include in such a risk analysis of coastal flooding, the socio-economic dimensions of this hazard. If possible, such an analysis should reveal (to the extent that this is feasible), the temporal dimensions in the years to come of foreseen damages and costs of any measures that need to be taken.

5.4.7 Heavy/Extreme Precipitation

While, in 2024, we focussed on observations and projections for Europe, the review of some studies with a world-wide focus indicated a lack for observational data for certain regions of the world. Even for Europe, high-quality observational data for extreme precipitation is lacking (gridded data covering a long time horizon is needed). Thus, if EASA deems it important that the picture for current changes can be completed (and to have a data set to calibrate simulation models with), it could take action to express their interest towards European or international initiatives, however, the only pan-European initiative that exists for gridded observations with a daily resolution[10][11] is the European Climate Assessment & Dataset (ECA&D) project Thus, the ECA&Dproject could be a first point of contact for further discussions and advice for a observational data set with sub-daily resolution.

For heavy/extreme precipitation, we can reiterate one point already touched for severe convective storms and hail in Subsection 5.4.1: dynamical downscaling/convection-permitting models (see Appendix A, section A.4.1) are already widely used in recent studies on heavy/extreme precipitation and the technique allows more accurate reflection of convection and can simulate perils impacting humans. Edmund Meredith and Uwe Ulbrich underlined that the high-resolution models are driven by GCMs through so-called initial and boundary conditions (that is, wind components, temperature etc. are simulated in global models, which are input to the high-resolution models). However, there exist large differences between different GCMs. To overcome the uncertainty from these different models, ensembles of downscaled, high-resolution global models are needed. Studies with these high-resolution global models are computationally expensive. Hence, if EASA is interested in studies using such ensembles of downscaled models, we recommend communicating this to the scientific community and all relevant research programs (such that funding can be obtained for creating ensembles of these models).

As for convective storms and hail, the number of future-trend extreme-precipitation studies for the middle of the 21st century is limited. The main reason is also the same: it is easier to obtain statistically significant results (which are of more interest to the research community) for the end of the century, as changes progress over a longer time. However, the economic lifecyles of both large aeroplanes, infrastructure and ground systems supporting the large aeroplanes is about 30 years. Thus, decisisions by EASA and other aviation stakeholder could benefit more from results for the middle of the century. These are possible to obtain with the current methods. Hence, if EASA estimates that a broader assessment of trends for the middle of the century are needed, EASA should communicate this need to the scientific committee and to all relevant research programs.

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[10] https://www.ecad.eu/download/ensembles/download.php, however, the station density there varies greatly, and Dr. Edmund Meredith highlighted that even this dataset is known to miss out on many small-scale events.

[11] There is a global initiative, but with lower resolution than that of E-OBS, by the global precipitation climatology project, https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00999

Additionally, as discussed in detail in Appendix G, Section G.2.2, percentile-based methods (using percentiles of of probability density functions (PDFs)[12] of daily precipitation are used to measure changes in extreme precipitation. This allows comparisons between regions, which absolute values would not enable (a certain precipitation amount could constitute a lot for one region, while it would be hardly any change for another). However, if EASA deems it important to gain insight into projected absolute values for certain regions, it should communicate this need to the scientific community.

Finally, reducing any of the uncertainties listed in Subsection 5.3.7 could lead to improved projections.

5.4.8 Jet Streams and their effects on weather patterns

The uncertainties related with the mechanisms affecting the jet streams and with their effects on weather conditions are admittedly large. The uncertainty of the models' results is also critical. The inter-model spread is not negligible, and it is attributable to different simplifying parameterizations employed by state-of-the-art climate models and those can, in a complex, non-linear system, lead to very different outcomes. Some of these discrepancies are caused by different responses in the Pacific and Atlantic regions, seasonal differences in the response, the use of different diagnostics and metrics, and/or biases in models and differences in experimental design.

Recommendations are therefore to deepen and widen the investigation on the variability of jet streams and its effects on weather patterns, that can pose significant threats to aviation. The scientific literature on the subject is quite rich. Interviews with different research teams may be helful to better compare results that may seem to be contradictory.

[12] A **probability density function** gives a function of a continuous random variable, here, the precipitation (amount), describing how likely it is that the random variable attains a specific value, here, that a specific amount of precipitation falls. Both the violet and the red curve in **Fehler! Verweisquelle konnte nicht gefunden werden.** give a PDF of precipitation. We observe that the PDFs for precipitation are skewed to lower values, that is, lower precipitation is more likely than higher precipitation. A **percentile** gives a value below which a certain percentage of values in the distribution fall: for the 99th percentile of the PDF of daily precipitation, 99% of the precipitation scores are below the precipitation threshold (and only 1% yield a precipitation amount above that precipitation threshold).

6 Report of Task Force #3: Artificial Intelligence

6.1 Introduction and Scope

The EASA's Scientific Committee provides advice on scientific issues that may influence the future development of the EASA expertise in scientific and technical domains linked to research, innovation, and disruptive technologies. In this respect, Artificial Intelligence was proposed by EASA as one of the most pressing topics to investigate jointly in the frame of a dedicated **'EASA SciComm AI task force'**.

The adoption of Artificial Intelligence in safety-critical aviation applications has progressed significantly over the past five years. This evolution has initially been driven by advancements in deep learning, which deliver high-performance, efficient solutions, particularly in computer vision and natural language processing, and expands progressively to a wider spectrum of AI techniques, in particular in the field of symbolic and hybrid AI. These developments are now enabling concrete applications in every domain of aviation.

In May 2023, EASA released its Artificial Intelligence (AI) Roadmap 2.0, taking the human-centric and ethics-driven approach to the integration of artificial intelligence (AI) in aviation one step further. The updated roadmap expands upon the initial proposal that was published in February 2020, drawing upon the experience gained from concrete AI use cases involving stakeholders from the aviation industry, academia, and research centres.

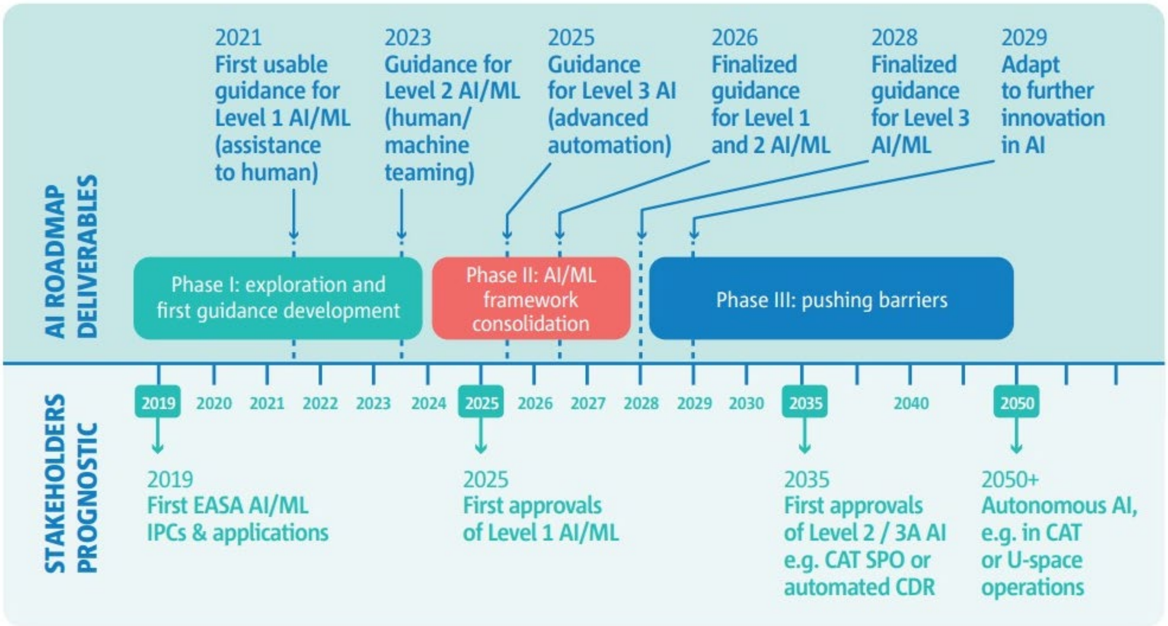


Figure 6-1: EASA AI Roadmap Timeline

In support of the EASA AI Roadmap implementation effort, the Scientific Committee AI Task Force agreed in 2024 to pursue the investigation in three parallel work streams, on the basis of the published **Concept Paper 'First usable guidance for Level 1&2 machine learning applications' Issue 02** from March 2024 (building on the three work packages #3, #4 and #5 from the 2023 AI Task Force activity):

Work package #6 – The Work Package number 6 aims to study, understand and build guidance for the Ethics in Artificial Intelligence for Aviation matters. On the basis of the EASA AI Roadmap, the EASA Concept Paper (Issue 01) and the draft EU AI Act, several activities were developed in 2023 already giving inputs for the EASA Concept Paper (Issue 2).

Work package #7 – The SciComm AI Task Force has in 2024 entered in the evaluation of the **Level 2 AI guidance dedicated to Human-AI teaming (HAT) and development of design principles for Level 3A AI**. The AI Task force supported the identification of relevant use cases to test and identify changes to the existing human factors objectives (HF-xx) and drafted specific objectives to account fo the specific 'safeguarding' nature of Level 3A operations.

Work package #8 - knowing that a number of use cases in **advanced automation AI (Level 3 AI)** are already in preparation, in particular related to drones, innovative air mobility or U-space operations, it is essential for EASA to start anticipating the main driving principles for this future development towards the deployment of more advanced automation powered by AI. What best forum than the Scientific Committee AI Task Force to pave this way.

6.2 Work Plan and Methodology

Before entering in the work plan and methodology, let's first highlight the AI Task Force team composition:

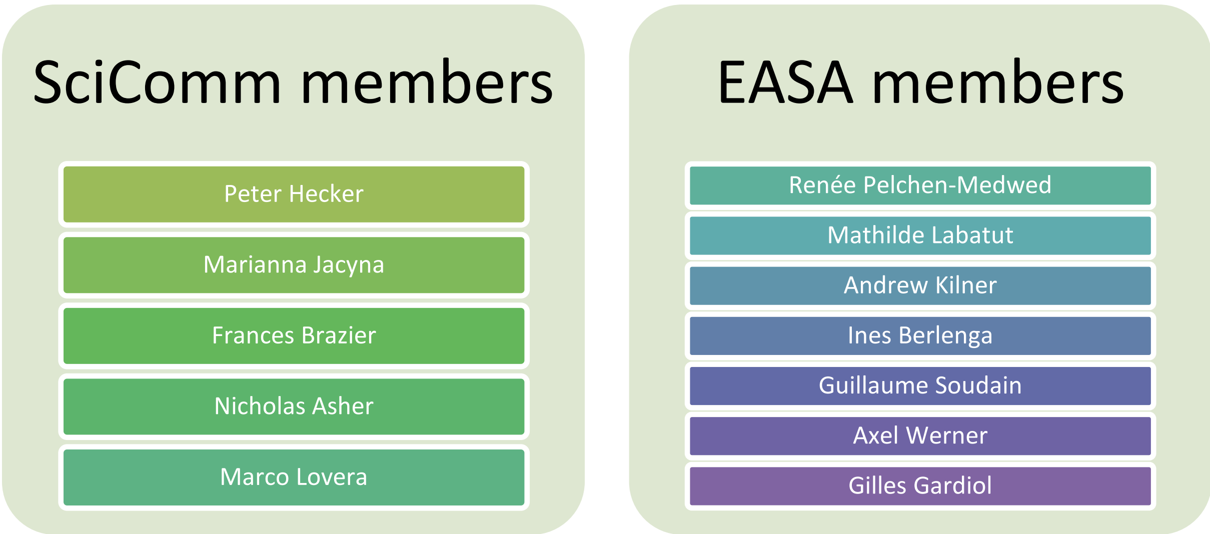


Figure 6-2: Task Force Composition

The work of the EASA Scientific Committee AI Task Force has been organized through the following work plan for the 2023 activity:

→ **Work Package 6: Ethics based assessment (target beginning Q4/2024)**
  → Support to the technical reporting on the ethical AI survey to aviation professionals.
  → Support to development of ethical AI survey for general public professionals.

→ **Work Package 7: Testing of the Human-AI teaming guidance (target beginning Q4/2024)**

- → Testing Level 2 AI Human Factors guidance with the identified use case
- → Further develop teaming concepts for Level 3A in view of EASA Concept Paper Iss. 03.

→ **Work Package 8: Anticipation of design principles for Level 3 AI (target beginning Q4/2024)**

- → Support development of design principles (Level 3 AI) in view of EASA Concept paper Issue 03.
- → Selection of use cases for Level 3B AI.

Following the kick-off meeting for the AI Task Force on the 6th March 2024, the activity of has been conducted through 8 virtual plenary meetings of 2 hours and 19 workshops of 1 to 3 hours.

In addition, a debrief from the activity of the AI Task Force has been presented at the general EASA Scientific Committee 3rd plenary meeting on 6th November 2024.

6.3 Key Findings in 2024

Work Package 6: Ethics based assessment survey

EASA WP6 interacted with the Scientific Committee seeking advice and validation in particular for the guidance drafted on the Concept paper (issue 2) concerning the Ethical based assessment, namely the definition of Objectives not covered by the current Regulations.

The objectives concerning Ethics were the following:

- Objective ET-01: The applicant should perform an ethics-based trustworthiness assessment for any AI-based system developed using ML techniques or incorporating ML models;
- Objective ET-02: The applicant should ensure that the AI-based system bears no risk of creating overreliance, attachment, stimulating addictive behaviour, or manipulating the end user's behaviour;
- Objective ET-03: The applicant should comply with national and EU data protection regulations (e.g. GDPR), i.e. involve their Data Protection Officer, consult with their National Data Protection Authority, etc.;
- Objective ET-04: The applicant should ensure that the creation or reinforcement of unfair bias in the AI-based system, regarding both the data sets and the trained models, is avoided, as far as such unfair bias could have a negative impact on performance and safety;
- Objective ET-05: The applicant should ensure that end users are made aware of the fact that they interact with an AI-based system, and, if applicable, whether some personal data is recorded by the system;
- Objective ET-06: The applicant should perform an environmental impact analysis, identifying and assessing potential negative impacts of the AI-based system on the environment and human health throughout its life cycle (development, deployment, use, end of life), and define measures to reduce or mitigate these impacts;
- Objective ET-07: The applicant should identify the need for new skills for users and end users to interact with and operate the AI-based system, and mitigate possible training gaps;

- Objective ET-08: The applicant should perform an assessment of the risk of de-skilling of the users and end users and mitigate the identified risk through a training needs analysis and a consequent training activity.

For these Objectives the Scientific Committee also were consulted for the anticipated Means of Compliance expected while doing their implementation.

More recently, the Scientific Committee was consulted for the identification of a set of scientific papers considering Ethics in Ai for Aviation and public perception, the list of circa 20 articles in now being analysed and will revert to the conceptualization of the next survey, that is planned for 2025, this time having the general public as respondents.

Work Package 7: Testing of the Human-AI teaming guidance

The aim of work package 7 was twofold in 2024. One aim in 2024 was to test the Human – AI teaming objectives for AI level 2A on the basis of the Boeing auto-taxi use case. The second aim was to further develop teaming concepts for Level 3A in view of EASA Concept Paper Iss. 03

1) **Testing Level 2 AI Human Factors guidance with the identified use case.**

Together with the scientific committee a document was drafted to identify the objectives that were relevant for a AI level 2A use case. It was checked which of the objectives were applicable, what information identified it as objective for AI level 2A and what information was missing to specify if the objective is indeed an AI level 2A objective. Further it was assessed if the objectives were clearly formulated and if they were indeed facilitating the development of an AI level 2A based system.

As the use case was not described in detail additional meetings were organised with the Boeing colleagues to gain more information on the use case.

2) **Develop teaming concepts for Level 3A**

The second aim in 2024 was to further develop teaming concepts for AI level 3A and identify AI level 3A objectives for the next issue of the concept paper.

In the same manner how the human AI teaming concept for AI level 2A and 2B were identified, the teaming concept for AI level 3A was drafted (Fig. XX).

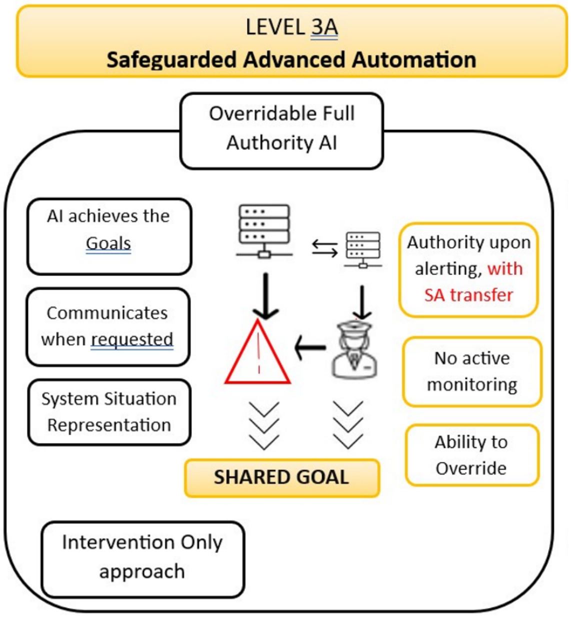


Figure 6-3: Human AI teaming in AI level 3A

The main difference compared to Level 2 AI is that the communication with the human is initiated by the AI based system and occurs therefore on request only. Whis leads to an authority of the human upon altering. The end user has still the right ot override the system. It is characterised as an intervention process.

As the next step it was aimed to identify objectives for AI level 3A. In order to do those two imaginary use cases were developed – one from the ATM domain and one from the UAS domain.

During the European Association for Aviation Psychology (EAAP) conference (held in September in Athens) a workshop was organised. The participants of the workshop were asked to identify Human – AI teaming requirements that should be put on the system development for both use cases. After the workshop the objectives were collected and the new objectives were identified and documented.

Together with the scientific committee the objectives were assessed to identify if the objectives are indeed AI level 3A objectives. Then the objectives were newly sorted and partly rephrased.

The output of both activities will directly feed into the EASA concept paper issue 3.

Work Package 8: Anticipation of design principles for Level 3 AI (advanced automation)

In the EASA AI Roadmap, Level 3 AI systems, termed 'advanced automation', have significant authority, with two sub-levels: 3A, where the AI makes decisions and performs actions under human safeguarding, and 3B, where the AI operates independently without active human oversight.

In line with **the definitions of 'automation', 'advanced automation' and 'autonomy' from the EASA AI Roadmap v2.0**, the consideration that automation and autonomy are distinct topics has been reinforced by the Scientific Committee in its 2024 activity. Automation is referring to the use of systems without human intervention, whereas autonomy is a characteristic of an advanced automated system.

> **Autonomy** — Characteristic of a system that is capable of modifying its intended domain of use or goal without external intervention, control or oversight[10].
>
> **Advanced automation** — The use of a system that, under specified conditions, functions without human intervention[11].

In this context, the **first major activity** concerned the anticipation of **alignment of the Level 3 AI principles with the EU AI Act Article 14 on 'Human Oversight'**. This article introduces the fundamental notion of effective oversight of AI-based systems by natural persons at the time where the system is operated. Depending on the Level of AI (based on the EASA AI Concept Paper definitions), this paragraph may raise important challenges:

- For Level 3A AI (safeguarded advanced automation), the presence of an end user in the loop of operations meets a large part of the requirements however there is a clear need to clarify the modalities of an "effective oversight" under remote monitoring conditions. Yet the remote nature of the human safeguarding requires a similar interpretation of Article 14.
- For Level 3B AI systems, the presence of a natural person in the loop of operations is not ensured directly. The anticipation by the aviation community of operations such as drones delivery in urban environment under U-space management pushes de-facto the interpretation of natural person oversight further. Therefore there is a need for setting the allowable boundaries of a "delegation" of oversight to systems at operational time, based on the pre-requisite of full development-time oversight as required in EASA AI guidance.

This reflexion led EASA to prepare a **Position Paper** in order to support the discussions with the EU Commission on on the way to orient the Level 3 guidance to ensure that advanced automation systems could be operated and effectively overseen thanks to introducing a model emulating natural person oversight, while ensuring a same or higher level of safety. The paper discussion focused on Level 3B AI-based systems but also serving the purpose of Level 3A, in which the operations under remote human safeguarding would require most of the time the same level of authority and independent oversight than Level 3B. The full position paper is provided in section 10 of this report and has been reviewed and supported by the Scientific Committee AI Task Force.

The **second major activity** consisted in **giving shape to the concept of independent 'operational oversight system'.** This went in two steps: defining the possible architecture of such a system and framing the extent of functionality expected to be performed by such a system, in analogy with the existing safety function performed by pilots in cockpits.

The architecture of a Level 3A AI-based system was inspired from the current operations, for instance in large commercial aviation operation, while keeping in mind the use case of a remote operator, for example overseeing a fleet of drones for parcel delivery. This led to sketch the following 'system of systems' architecture:

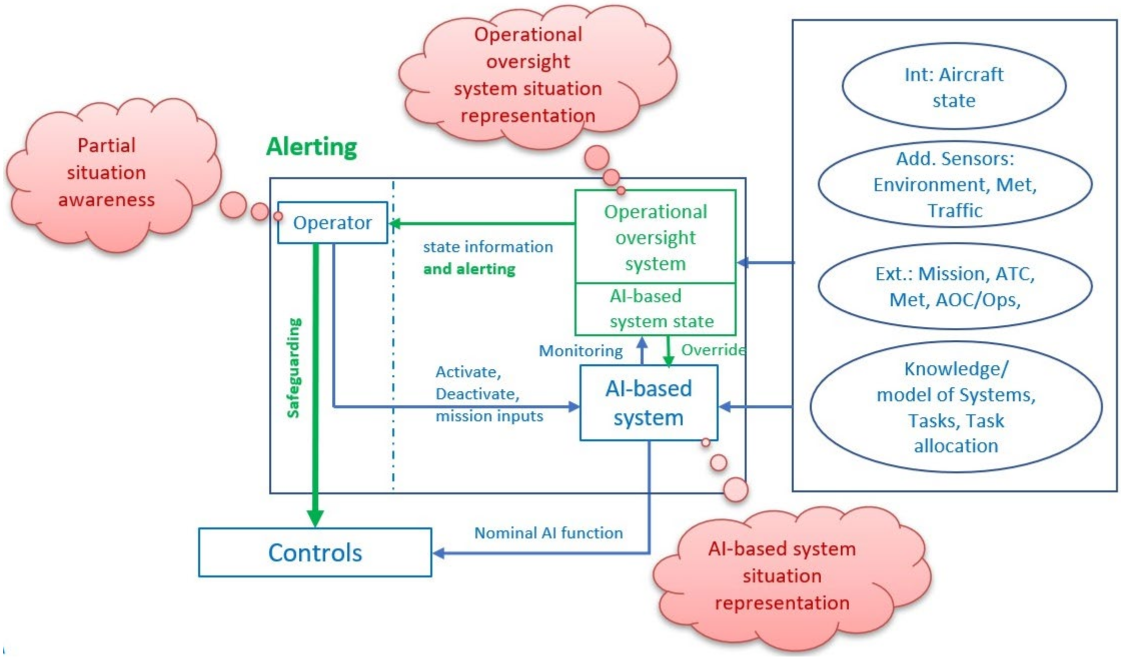


Figure 6-4: Architecture of a Level 3A AI system of systems (safeguarded advanced automation)

The 'operational oversight system' is the central element in the system architecture which should take over the oversight of the 'AI-based system' that was ensured by human end user(s) in the Level 1 and 2 AI concept. This system has at least three important high-level tasks:

Independent monitoring of the AI-based system based on an independent situation representation, based on the inputs received by the AI-based system, on the AI-based system state and on any additional information necessary to build a dissimilar perspective of the operation

Overriding of the AI-based system to recover from abnormal situation that remain in the Operational Domain of the 'Operational Oversight System'

Alerting the Operator in case of detection of a situation that requires Operator mission related input or of situation that are out of the Operational Domain of the 'Operational Oversight System', in both cases ensuring a proper transfer of situation awareness to the Operator.

In 2025, this concept shall be further developed in the EASA AI Concept Paper Issue 03, with support of the Scientific Committee AI Task Force.

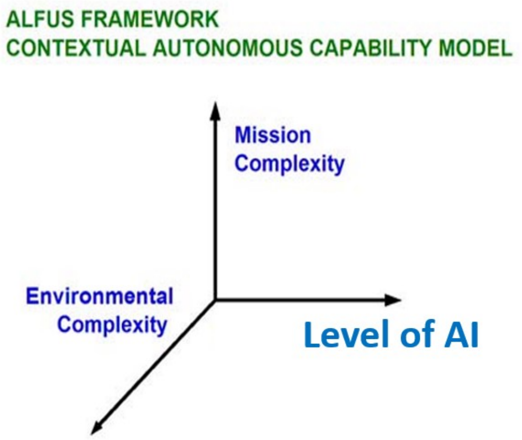
The **third** activity explored the type and nature of monitoring tasks that should be taken over by such an 'Operational Overisht System'. To this purpose the WP8 team interviewed one external Pilot, two EASA Pilots and one EASA Flight Test Engineer to identify the cognitive functions involved in two different use cases:

- Use case #1 (inspired from BEACON Innovation Partnership Contract between EASA and Boeing): an auto-taxiing system receiving, via standard radio communication, taxi clearance from ground control, providing a readback of the clearance, planning the appropriate route based on that clearance and executing the plan, automatically controlling the aircraft as it travels from one location to another at an airfield, while detecting potential obstacles in the aircraft's path to which it reacts accordingly. This first example allowed to list a number of relatively simple cognitive tasks performed by the pilot that could be realistically embedded in the 'Operational Oversight System'. Is also highlighted the complexity of managing certain cognitive tasks linked to the uncertainty of the operation, such as 'anticipating future situation based on experience, intentions, weak signals'.

- Use case #2 (inspired from helicopter off-shore operations): a digital assistant would support flight management aspects (fuel and weight), performing the 'flight planning' in cooperation with the Crew, providing a 'brief' on the selected route before the flight starts, and updating the route in flight, managing all the information that is received from the different sensors (weather stations, helidecks., etc). While this operation is complex and involves a dynamic environment, the description provided by the Pilot demonstrated a management of uncertainty in the current operations which would allow to allocate numerous monitoring tasks to the 'Operational Oversight System' and potentially emulate accurately the cognitive monitoring performed by the Pilot.

In 2025, these cases could be further explored and further similar investigation could be launched based on use cases from other aviation domains.

The **fourth activity** allowed to outline the important criteria orienting the **possible classification of operations in terms of their complexity**. It built on the model proposed by the NIST ALFUS paper and can be summarized with the following figure:



→ **Mission complexity:**
  → Knowledge requirements
  → Level of collaboration required (tasks decomposition/allocation analysis)
  → Dynamic planning
  → Real-time risk/benefit analysis (trade offs)
  → Situation awareness (perception, comprehension, projection)

→ **Environment complexity**
  → Dimensionality of OD/ODD
  → Dynamic nature
  → Uncertainty analysis

Figure 6-5: Anticipated criteria for defining operational complexity according to NIST ALFUS

Note that the criteria is mainly based on mission complexity and environment complexity, the Level of AI replacing the ALFUS automation scheme.

See section 11 to access the detailed research report and refer to the sources used for this analysis.

6.4 Conclusions for the AI Task Force activity in 2024

The AI Task Force activity in 2024 has been instrumental for the EASA AI Programme, supporting the the preparation of the report for the first AI Ethics Survey for aviation, refining the set of Human Factors objectives for Human-AI teaming, and anticipating a first set of principles for the development of Level 3 AI guidance (advanced automation).

6.5 Recommendations for future work within the AI Task Force

The AI Task Force team recommends to extend the activity of the AI Task Force in 2024 to address the next upcoming priorities of the EASA AI Programme:

- → **Work Package 9: Ethics based assessment**
  - → Support to general public survey (Part II) data analysis and report review
  - → Support to update of guidance on ethics-based assessment in view of EASA Concept paper Proposed Issue 03

- → **Work Package 10: Testing of the Human-AI teaming guidance**
  - → Testing Level 3A AI Human Factors guidance with the identified use case
  - → Support to final guidance development for the 'HF for AI' building block

- → **Work Package 11: Anticipation of design principles for Level 3 AI applications**
  - → Support development of design principles (Level 3 AI) in support of EASA Concept Paper Issue 03
  - → Selection of use cases for Levels 3 AI.

7 Conclusions

The EASA Scientific Committee continued its work in 2024 and successfully completed its third full annual cycle of activities.

On the organisational level the SciComm has further followed its internal process for organizing its workflow. This process has proven its suitability also over the third year as it has ensured an efficient operation and delivering maximum support to EASA. Along the turn over to the fourth year of operation, the tree Task Forces have been continued with some adjustments and their work programme has been updated according to the needs of EASA and the recommendations provided by the Committee in 2024. They continued delivering important results, which have been summarized in this report. All three Task Forces delivered output relevant for short term considerations (to be taken up immediately enabling “quick wins”) as well as for long term considerations supporting the strategic level.

In order to develop a structured approach to connect academia with EASA, and later potentially with other stakeholders, the scope of the former PhD Taskforce has been reviewed and refocused. Within the newly established Academia Network Task Force (ANTF), which replaces the former PhD Taskforce, the concept of an Academia Networking Platform (ANP) has been developed to enhance collaboration and leverage expertise, and to systematically identify and prioritise key research areas. As a result, a detailed blueprint with recommendations and a roadmap for implementation has been developed through a partnership with an existing knowledge transfer network.

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The newly established Academia Network Task Force has made significant progress in developing a blueprint for an EASA-Academia Networking Platform to build a sustainable partnership between academia and EASA. This blueprint describes a structured approach that will, in the longer term, allow the creation of a collaborative environment to identify and promote key scientific developments that have the potential to enhance the safety, security and environmental sustainability of civil aviation. It will also help EASA to identify the knowledge, competencies and skills required for the training of the next generation of aviation professionals, as well as proposals to address the gaps. In the short term, this blueprint provides guidance on how to join forces with other European initiatives and undertakings to establish such a network. The Task Force has also considered a second scientific event to follow up the highly successful EASA PHD Conference held 2023.

According to the research works reviewed by the **Task Force on impact of climate change**, there are consistent indications that climate change has the potential to contributing to several further significant threats to aviation.

The rising of sea level due to climate will continue in the near future, contributing to a growing risk of coastal flooding. Coastal and low-lying airports in Europe are at an increasing risk of flooding, impacting the planning of new infrastructures and the operation of existing infrastructures. It is recommended to launch deeper investigations using recent IPCC climatic projections in order to establish a coastal flooding risk map for the airports in Europe. Ideally, the estimated risk should be presented in probabilistic terms, thus allowing the users to prioritise actions and to include the socio-economic dimensions of this hazard.

For extreme precipitation in Europe, the increases in extreme (sub-daily) precipitations are projected to continue, with both increases in intensity and frequency. Moreover, the frequency increases more for more intense rainfall events than for events with lower intensity. The increases for extreme precipitation occur even in regions where mean precipitation is projected to decrease. A lack for observational extreme sub-daily precipitation data for certain regions of the world has been recognized. Even for Europe, high-quality observational data for extreme (sub-daily) precipitation is lacking, while gridded data covering a long-time horizon would be needed. It is recommended to connect with existing pan-European initiatives for gridded observations with a daily resolution. In addition, the number of future-trend extreme-precipitation studies for the middle of the 21st century is limited. However, EASA and other aviation stakeholder could benefit more from results for this time period. Finally, to overcome uncertainties from current models, the provision of ensembles of downscaled, high-resolution global models should be initiated.

Regarding jet streams and their effects on weather patterns it has been reported that their evolution may impact hazard seasonality, magnitude, geographical and time coverage, and uncertainties significantly. However, the uncertainties related with the mechanisms affecting the jet streams and with their effects on weather conditions are admittedly large and the uncertainty of the models' results is also critical. Therefore, it is recommended to support deepening and widening the investigation on the variability of jet streams and its effects on weather patterns, that can pose significant threats to aviation.

The **AI Task Force** activity in 2024 has been instrumental for the EASA AI Programme, supporting the preparation of the report for the first AI Ethics Survey for aviation. **On the short-term** the Committee provided guidance on the Concept paper (issue 2) concerning the Ethical based assessment, namely the definition of objectives not covered by the current regulations. The survey was supported by a survey on scientific papers considering Ethics in Ai for Aviation and their public perception.

On the longer term, the Committee supported the testing of the Human-AI teaming guidance in a twofold sense: on one hand the Human-AI teaming objectives for AI level 2A have been tested on the basis of a commercial use case on auto-taxiing; on the other hand, the set of Human Factors objectives for Human-AI teaming were refined and a first set of principles for teaming concepts for Level 3A in view of EASA Concept Paper Issue 03 was anticipated.

A reflexion on the alignment of the Level 3 AI principles with the EU AI Act Article 14 on 'Human Oversight' resulted in the preparation of a position paper supporting the discussions with the EU Commission on the way to orient the Level 3 guidance. In addition, relevant building blocks for Level 3 AI such as the concept of independent 'operational oversight system' and the related of monitoring tasks taken over by such system were explored. As a complementary activity, important criteria were investigated orienting the possible classification of operations in terms of their complexity on a model proposed NIST ALFUS.

8 References

(2021). *Terms of reference for EASA.2019.CEI.14.EC010: Scientific Committee.*

9 Supporting Material: EASA-Academia Networking Platform Blue-Print

General

This blueprint for an academic networking platform aims to create a dynamic collaborative ecosystem that allows a continuous productive dialog amongst academic institutions and between academia and EASA to address the challenges and opportunities within the aviation sector. By facilitating focused research, innovation, and knowledge exchange, the platform aims to contribute to the advancement of aviation safety, security and environmental sustainability and related technology. The following blueprint outlines the general structure, operations, objectives, and mechanisms for engagement and collaboration within this proposed network.

Objective

The principal objective of this platform is to enhance and streamline collaboration among academic institutions, and between academia and EASA with a view to identifying and promoting major scientific developments that have the potential to advance civil aviation safety, security and environmental sustainability.

This collaborative endeavor is designed to assist EASA in fulfilling its obligations under Article 86 of the Basic Regulation by providing expert scientific advice identifying and prioritizing important research needs, emerging challenges and technologies, and thereby contributing through the SciComm and EASA to the Commission's research agenda. It also serves in helping EASA to identify the necessary knowledge, competencies, and capabilities for the education of next generation aviation professionals as well as proposals to close the gaps.

Structure and Operations

1. **Academic Networking Platform (ANP) (details see Annex 1):**
   A digital portal for participating members and observers that serves as the central hub for interaction, collaboration, and information exchange among academia and EASA. The platform would include:

   - A general open forum (web-based platform) to share information on and discuss ground-breaking research and innovation trends, needs and priorities.
   - Dedicated special interest groups (SIGs) on specific emerging aviation research topics of paramount significance for the aviation sector or disruptive nature.
   - A mechanism to support the collection, evaluation and sharing of information on ground-breaking research activities, outcomes, and publications.

- A repository for industry challenges that require academic expertise.
- A potential cooperation with ENGAGE2 the bridge between academia and industry in the ATM domain.
- A tool for advertisement of PhD tasks or expression of research interests by students, as well as matching research capabilities, project cooperation, and mentorship opportunities for PhD students

2. **Special Interest Groups (SIGs)(details see Annex 2):**
    - Organized around specific domains or emerging research topics of paramount importance or disruptive nature, as identified by the SciComm in consultation with EASA. Could inspire young researchers and help identify topics for PhD students that are relevant for safety regulatory bodies and their domains of expertise (e.g. airworthiness of aeronautical products).
    - Would support the definition of new training packages aimed for safety regulatory bodies, in particular for domain experts, addressing novel technologies or solutions for civil aviation and the related safety issues.
    - Led by a chairperson to encourage horizontal cooperation and work sharing among universities and industry partners.
    - Activities could include monthly, bimonthly, or quarterly online webinars or workshops, facilitating focused discussions and collaborative research efforts.
    - SIGs share their reports, opinions and recommendations with the ANP, the SciComm and EASA.
    - EASA in consultation with the SciComm will review and decide on any follow up action including the presentation of the outcome at conferences.

3. **Innovation Conferences, Workshops and Webinars (see Appendix A):**
    - Innovation Conferences (Academic Innovation Forum) will be organized bi-annually, possibly alongside or embedded within EASA's safety conference.
    - Provide an opportunity for in-person meetings, presentations of research findings, discussions on industry challenges, and networking.
    - Provides an opportunity to award outstanding achievements by academia or individual researchers/PhD students.
    - Workshops and/or webinars will be organized predominantly online by Special Interest Groups (SIG) to enable the exchange on developments thru information and viewpoints on pre-identified scientific topics/questions/issues.

4. **Engagement with MSCA and Other Funding Mechanisms:**

- Encourage academia to develop proposals for establishing doctoral networks focused on aviation-specific themes (e.g., icing, drones, sustainability, digitalization etc.).
- Facilitate the grouping of organizations from academia, industry, and research bodies to support coordinated education and research efforts.

  Leverage existing funding mechanisms (e.g., MSCA) for supporting PhD students and research projects.

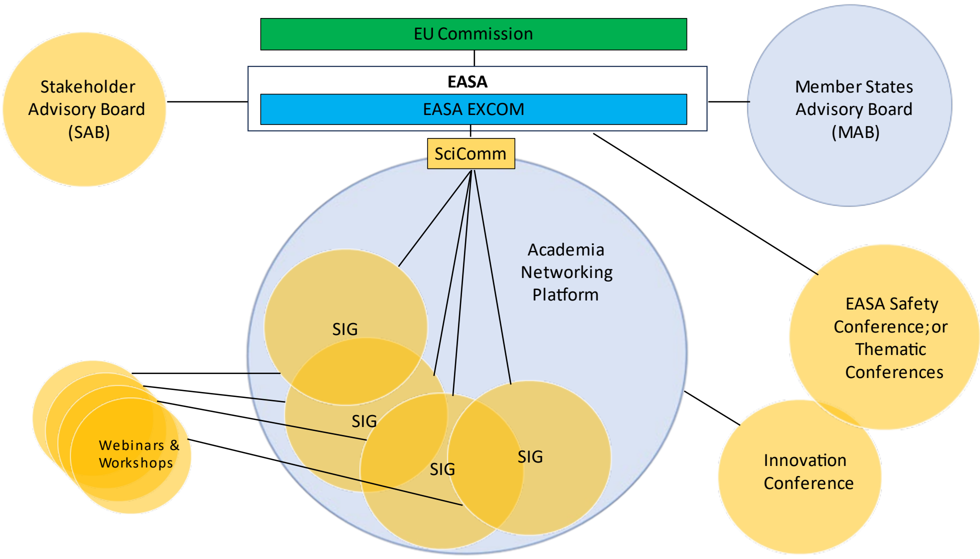
5. **Data Management and Protection:**
   - Develop adequate policies and protocols for collecting, archiving, processing, and sharing data within the ANP in compliance with the GDPR regulations.
   - Implement measures to protect against unauthorized data access.
6. **Feedback and Communication Mechanism**
   - Regularly share information with stakeholders through reporting and information sessions.
   - Implement a feedback and evaluation mechanism to collect, analyze, and evaluate feedback for process and outcome improvement.
   - Establish communication tools to support dialogue between ANP members.

Governance and Supervisory Functions

The following illustration (picture 1) explains the organizational integration of the Academia Networking Platform (ANP), as defined in para 1, with the EASA structure through the SciComm. The governance and supervisory functions for the ANP are provided with the support of the scientific committee. They ensure that the network's activities align with EASA's overarching objectives and ethical guidelines. The SciComm reports directly to the EXCOM.

Consultation, coordination, and consolidation with EASA's Advisory Boards (MAB and SAB) are ensured through EASA's operational units and hierarchical reporting lines. The Agency provides advice to the Commission in accordance with Art 86 of the Basic Regulation.

EASA, while central to the thematic relevance of the network, engages with the network without requiring additional resources on its part. Collaboration with the network allows to leverage external expertise and resources.



Picture 1: Organisational integration between EASA and the academia platform through SciComm

The ANP shall provide visibility, networking opportunities, and help find potential funding avenues for participating entities, encouraging active involvement and contribution.

It may also encourage the formation of research groups that span multiple disciplines and sectors, recognizing that innovation often occurs at the intersection of different fields (e.g., combining aviation with computer science, environmental science, or healthcare).

The network should seek partnerships with existing academic and professional networks outside of aviation to cross-pollinate ideas and technologies that could benefit the aviation sector.

Funding

Finding the necessary resources and providing adequate funding may pose a major challenge. EASA's current budget for the coming year does not include this new initiative. The progress of the budgetary process and the importance of other priorities make it unlikely that more funds can be mobilized in the near future.

This calls for alternative options and a sharing of the financial burden by participating stakeholders.

Options 1: Consider implementing a membership fee for participating institutions (complementary to other funding options).

Option 2: EASA to seek stable funding through its annual budget.

Option 3: Approach the Commission and seek financial support considering that the Commission is also financing the ENGAGE project with relatively large sums.

Option 4: Enter into a partnership with S3JU and Deepblue and expand (or copy) the ENGAGE 2 project from ATM to all areas of aviation safety, security, and environmental sustainability.

Note 1: It is considered that option 1 is likely not a viable funding solution on its own, however it is retained as complementary funding as part of a basket of funding sources.

Annex 1: Procedural Guidance for the establishment and operation of an Academia Networking Platform (ANP).

Establishment of the ANP:

The ANP is established through a public call for interests that is launched via the EASA website complemeted by direct correspondence to relevant stakeholders as identified by the SciComm. Stakeholders are academic institutions and individual researchers as well as PhD students.

Objectives and tasks

The main objective of this initiative is reflected in the main paper under objectives. To this end, the following individual tasks must be achieved by the ANP and SciComm:

i. Facilitate Collaboration:
    a. Find ways that enable easy discovery of potential collaborators across various fields and institutions.
    b. Support virtual meetings, joint research, and collaboration through SIGs
ii. Promote Knowledge Sharing:
    a. Faciliate access to research papers, articles, and educational materials.
    b. Implement forums, webinars, and discussion groups for knowledge exchange.
iii. Build consensus amongst academia on significant topics
    a. assess the benefits of selected research activities for aviation safety, security and environmental sustainablity.
    b. Agree on priorities of research activities considering their societal impact as well as technological progress, and recommend those to EASA through the SciComm
iv. Enhance Academic Visibility:
    a. Offer opportunities where academics can showcase their work, publications, and achievements.
    b. Feed a recommendation system to highlight significant contributions and emerging researchers.
v. Support Professional Development:
    a. identify the competences needed by Next Generation Aviation Professionals (NGAP)
    b. Propose adjustments and evolution to academic curricula and help build new programs, courses and skill-building workshops.
vi. Maintain Data Security and Privacy:
    a. Ensure robust data protection measures are in place to safeguard user information.
    b. Comply with relevant European data protection regulations and ethical standards.

Membership:

- Eligibility:
  Membership is normally open to individuals from participating academic institutions. In justified cases additional members with specific expertise may be invited in their own right.

- Application Process:
  Interested academic institutions may propose individual candidates deemed suitable online via a web-tool (to be created). Their application should be accompanied with credentials issued and signed by their respective academic institution or an official ANP or SciComm member vouching for him/her.

- Selection of ANP Members:
  The SciComm reviews and proposes to EASA the selection of suitable candidates based on their respective expertise, experience, and interest. The invitation may be expressed on a case-by case basis or permanently. EASA as well as Members of SciComm are considered members “ex-officio”.

Operation:

The ANP under the guidance of the SciComm identifies through dialog with participating parties special research topics and establishes SIGs focused on those specific research areas or projects. Note: Appendix A to Annex provides some guidance for the identification of ANP initiatives and SIG topics.

Regular communication channels for an ongoing dialog are set up for the ANP using the web-tool. This shall facilitate chatrooms, virtual meetings, the sharing of newsletters, and updates.

The ANP establishes an organizing committee to plan, organize and manage annual conferences, workshops, and webinars to facilitate knowledge exchange and networking.

The SciComm monitors and evaluates the platform’s activities and impact, and makes the necessary adjustments to improve its effectiveness.

- Decision Making Processes:

  The SciComm is the main governing body of the ANP. It provides overarching strategic direction and governance and forms the link to EASA. It ensures scientific integrity and relevance of the platform’s activities vis-a-vis EASA’s mandate under Art 86 of the Basic Regulation. It resolves conflicts and makes final decisions on escalated issues. It liaises with external scientific bodies and funding agencies. To this end, it fullfills the following tasks:

  - Adopt procedures for proposing, discussing, and approving initiatives, projects, and policies.
  - Identify and explore emerging or disruptive themes.
  - Determine topics for the SIGs
  - Establishment and supervision of SIGs

- Oversee the implementation of initiatives.
- Ensure alignment with the platform's mission and goals.
- Facilitate communication between ANP members, Special Interest Groups (SIGs) and SciComm.
- Advise on budget allocations for initiatives and projects

- <u>Reporting and interaction with EASA:</u>
  - Alignment with EASA's strategic goals and regulatory mandates shall be ensured through continuous dialogue and collaboration.
  - A system for gathering feedback from EASA and other stakeholders shall be established to inform on the platform's development and operations and its potential for further evolution.
  - Joint events and initiatives with EASA can help to promote the platform and its objectives.
  - The network shall receive regular progress reports/updates from working groups and SIGs combined with a verification of research progress/outcomes and the achievement of project goals. Evaluation can be done through regular evaluation meetings to discuss project results, issues, and plans.
  - Evaluation reports may serve as basis for SciCom reporting. Annual reports shall be sent to EASA, detailing the platform's impact on advancing research and innovation in civil aviation safety, security, and environmental sustainability.

Physical Infrastructure and Data Protection

An online networking platform shall be set up with the following functionalities/features:

- a website/front page that is open to the public to provide an overview and allow navigation to the various functionalities, published contents, information, and a password protected portal for members' access to a protected site.
- The website shall provide a secure, password protected communication tool to allow group chats and point to point dialogs for discussing specific topics, sharing insights, and seeking advice from peers and for teams to collaborate on research papers in real-time.
- Tools for managing collaborative research projects, including task assignments, timelines, and document sharing.
- Users shall be able to create and publish content, such as articles, reports, blog posts, and announcements. A shared online calendar should track upcoming academic events and deadlines.

- The system shall include a centralized database/repository for storing and accessing research papers, datasets, presentations, and other academic resources.
- Information on available grants, scholarships, and funding opportunities from various sources, as well as tools to assist in preparing and submitting grant applications.
- Data (cloud) centers located in countries with strong data protection laws and political stability. Multiple locations should be considered for redundancy.
- Physical infrastructure and data protection standards and measures that ensure reliability, security, and compliance with legal standards, and include back-up systems and disaster recovery plans.
- Compliance with the General Data Protection Regulation (GDPR) and other relevant data protection regulations shall be ensured.

Appendix A to Annex 1: Selecting Initiatives and SIG topics:

General

The SciComm with the support of the ANP identifies and selects proposals that meet criteria and align with strategic objectives. It estimates the necessary budget and resources for selected topics/initiatives, and documents/communicates their conclusions to relevant parties, in paticular to EASA. The SciComm will also endeaour to resolve any disputes or escalating issues.

The SciComm furthermore monitores with the help of the SIGs and the ANP the implementation of the selected initiatives. The following detailed procedures provide further guidance on the individual steps for the selection and review of SIG topics:

Procedures for Proposing, Discussing, and Approving Initiatives

Step 1: Proposal Submission

- **Who:** SIGs, Individual Members, SciComm

- **How:** Submit a detailed proposal using a standardized template provided by the Steering Committee.
- **Content:** Objectives, scope, outcomes, resources, timeline, impact.

Step 2: Initial Review

- **Who:** SciComm.
- **How:** Evaluate alignment with strategic goals, feasibility, and impact.
- **Outcome:** Feedback for revisions or advancement to the discussion phase.

Step 3: Discussion and Feedback

- **Who:** SciComm, SIGs, Proposers.
- **How:** Presentation, Q&A sessions, detailed assessment.
- **Outcome:** Comprehensive feedback and requested revisions.

Step 4: Final Proposal Review

- **Who:** Steering Committee.
- **How:** Review revised proposal, conduct final feasibility check.
- **Outcome:** Approval or further revision requests.

Annex 2: Procedural Guidance for the establishment and operation of Special Interest Groups (TORs)

General

Special Interest Groups (SIGs), with their concentration of expertise and focus on specific research areas within civil aviation, are well-positioned to help the SciComm and EASA identify current and emerging research needs and gaps in the field of civil aviation and support funding recommendations to the European Commission, particularly in areas related to aviation safety and environmental protection.

To this end they can also assist in the development of detailed research proposals that align with the European Plan for Aviation Safety and the Commission's priorities. Their expertise may help formulate projects that are robust, scientifically valid, and likely to yield beneficial outcomes.

Procedural Guidance for Special Interest Groups (SIGs)

The following procedural guidance on the formation, leadership structure, activities, governance, and reporting shall be applied for the establishment and operation of Special Interest Groups (SIGs) focusing on promising, high-profile scientific research areas in civil aviation.

1. Formation, Merging and Closure of SIGs

- Objective Setting:
  The SciComm in consultation with the ANP and EASA determines the need for the establishment of a SIG and defines clear, actionable objectives and deadlines for reports related to its specific area within civil aviation research.
- Size and Composition of the Groups
  The size and composition of SIGs should be determined by the SciComm based on their judgement on the nature and required expertise for the objectives of the group. In doing so, the SciComm should also keep in mind that the groups must remain manageable and can work successfully.
- Member Invitation:
  The SciComm reaches out to participating stakeholders (academic institutions) with a request for nomination of potential members with a demonstrated interest or expertise in civil aviation and in particular the subject at hand.

- Merging and Closure of Groups
  The SciComm decides after consultation with EASA and the chairpersons of the respective SIGs on the need to merge or to disband certain groups. SIGs shall be disbanded, when they have accomplished their tasks and delivered their final report, if they are deemed inactive or

dysfunctional and provide no added value, or developments have rendered the need for their continued existence questionable.

2. **Membership**

- Eligibility:
  Membership is normally open to individuals from participating academic institutions. In justified cases, when deemed necessary for the work of the group, additional members with specific expertise may be invited in their own right as either as special guests for one meeting or as permanent member.

- Application Process:
  Interested academic institutions may propose individual candidates deemed suitable online via a web-address (to be created). Their application should be accompanied with credentials issued and signed by their respective academic institution.

- Selection of Members and Observers:
  The SciComm reviews and proposes to EASA on the selection of suitable candidates based on their respective expertise, experience, and interest in the SIG's focus area, and its expectation that the candidate will add value to the deliberations and activities of the SIG. It is at the discretion of the chairperson of the SIG to accept a limited number of observers that do not fulfil the eligibility criteria for full membership, but where participation may be deemed useful. The invitation may be expressed on a case-by case basis or permanently. The number of accepted observers shall be kept in a reasonable proportion to the members and not exceed 20% of the entire group.

- EASA experts may participate (ESI to propose)

3. **Structure and Leadership**

- Selection of Chairperson:

  - Nomination:
    The chairperson must be a member of the SIG and can be nominated by another member of the SIG or by themselves. .
  - Election:
    The chairperson is selected from the nominated candidates in an anonymous vote by the SIG members for a renewable term of one year. If only one candidate has been nominated and no member contests, the chairperson is considered to be elected by acclamation. In such case there is no need for a vote. The chairperson is finally appointed by the SciComm based on the recommendation by the group.

- Roles and Responsibilities of the chairperson:
  The Chairperson coordinates the SIG's activities, leads meetings, manages communications, and serves as the point of contact for external parties. He/she represents the SIG externally.

4. Objectives, Benefits and Outcomes

- Objectives
  The main goal of a SIG is to support the ANP's objectives as defined in the main body of this paper by fostering a community of leading academics and researchers. They explore emerging trends, address challenges, and contribute to new technologies and methods in civil aviation. SIGs aim to share expertise, promote collaboration, and make impactful contributions to specifically selected fields or high-potential in civil aviation.

- By organizing webinars, workshops, and collaborative projects, the SIGs seek to enhance understanding, encourage academic and professional growth, and influence industry practices and policy-making in civil aviation globally.

- Benefits and Outcomes
  SIGs can play a vital role in relation to article 86 of EASA's Basic Regulation by serving as a bridge between EASA, the Member States and the academic and scientific communities.

  SIGs help facilitate focused research on specific areas of high importance for aviation safety and environmental impact, aligning with EASA's priorities and EPAS objectives in particular with regard to identified/emerging safety issues. This can help in the development of new safety technologies, methodologies, and practices that are directly relevant to regulatory needs.

  SIGs are expected to help identifying major current and emerging research needs and gaps in the field of civil aviation, and pinpoint areas that require further investigation and support, thus providing proposals to the SciComm to advice EASA and help guide the EU Commission on the allocation of funding to the most impactful and necessary projects.

  By organizing workshops, webinars, and conferences, SIGs enable the exchange of cutting-edge knowledge and ideas between academia, industry, and regulatory bodies. This can lead to better-informed regulations and policies that are grounded in the latest scientific research and technological advancements.

  Another aspect is the identification and organization of PhD topics and related research activities. Through collaboration with SIGs, EASA can contribute to the shaping of educational programs and curricula that prepare future aviation professionals with the skills and knowledge necessary to meet the industry's safety and environmental standards.

  With the backing of academic and research-based evidence, SIGs can effectively advocate for changes or enhancements in aviation regulations. Their research outputs can provide the empirical support needed to propose amendments or new regulations that enhance safety and environmental protection.

5. Operations and Decision-Making Processes

- Regular Meetings:
  Regular meetings to discuss ongoing research, share findings, and plan activities shall be organized at intervals determined by the chairperson based on the views expressed by SIG members. Regular meetings are neither open to the public nor to parties or individuals whose participation has not been accepted.

- Webinars and Workshops:
  Coordinated by the chairperson the SIGs may schedule and plan webinars or workshops focusing on relevant and current topics in civil aviation.

  The chairperson is encouraged to engage guest speakers from academia, industry, or other research institutions to enhance knowledge sharing.

- Documentation:
  The SIG shall make arrangements to maintain thorough records of all meetings, including decisions made and progress on planned activities.

- Decision Making:
  SIGs reach their decisions by consensus under the coordination of the chairperson. In case of protracted discussions without a clear picture on what the group favors, the chairperson may ask for an indicative poll by show of hands. This is not to force a decision, but to help facilitate and steer the discussion towards a consensual outcome.

6. Communication and Reporting

- Reporting
  The chairperson shall coordinate and present regular update reports to the SciComm every time a significant progress or result in respect to the mandate of the SIG has been produced or upon request from the SciComm.

- External Communication
  The SIG may decide to publicize its work and events through newsletters, academic journals, and relevant social media platforms to inform and engage the broader community.

7. Evaluation and Improvement

- Annual Review
  At the end of each year, the chairperson initiates an evaluation of the SIG’s achievements versus its goals and reports it to the SciComm.

- Feedback Mechanism
  Members are invited to propose improvements or express concerns about the SIG’s direction or management.

- Adaptation to Developments
  SIGs may adapt their focus and activities within their subject matter mandate based on the latest in civil aviation research and feedback from members. Such adaptations need to be discussed by the SIG and proposed by the chairperson to the SciComm for adoption.

8. Sustainability and Funding

- Funding
  Working hours and other cost or expenses including travel and accommodation cost of the SIGs shall be borne by participating parties and are not subject to reimbursement from EASA. This applies also to guest speakers. Additional opportunities for funding of research activities through grants, partnerships with industry, and collaborations with academic institutions may be explored by the chairperson in consultation with the SIG members and the SciComm.

- Sustainability
  The chairperson shall help to ensure the sustainability of the SIG by monitoring its composition in terms of competencies, expertise and number of members, and report to the SciComm, if he/she perceives an inadequacy.

9. Sharing and Dissemination of Knowledge and Research Results

- Sharing of knowledge and research results
  SIG members are encouraged to share their knowledge and research results within their group or through the chairperson with other SIGs.

- Publication of Knowledge and Research Results
  SIG Members are encourage and shall be supported to publish knowledge and research results through the ANP platform and in consultation with the SciComm and EASA.

- Collaborative Research Projects
  SIGs are encouraged to facilitate collaborative research projects among members to further the field of civil aviation.

10. Confidentiality and Intellectual Property Rights

- Intellectual Ownership Rights
  Ownership of the information and material exchanged in the context of the collaboration of the SIGs and any results thereof - unless owned by a third party - will remain vested to the contributing Party. Under no circumstances shaill the mere possession of the information and material be interpreted as conveying express or implied ownership of intellectual property rights.

  Participating members and observers may access, view, retrieve, and print the information and material received in the context of the SIG proceedings and discussions. They may not republish, sell, rent or otherwise sub-license, reproduce, duplicate, copy and exploit the received material for a commercial purpose, edit or otherwise modify this material, or redistribute it, except for content specifically and expressly made available for redistribution. Every party that holds the intellectual property rights of the information or material is of course not affected by the above in publishing its own research results or knowledge if required by the applicable laws and statutes.

- Confidentiality
  Members and observers shall respect the highest confidentiality standards regarding the use and dissemination of the information handled within the context of their respective mandates. This means members and observers shall undertake to apply the necessary measures to ensure the appropriate confidentiality of the information or documents received in connection with their participation in a SIG, particularly if it is clearly labelled as "Confidential Information" by the disclosing Party, and to ensure that each person involved complies with such measures.

Appendix A:

	WEBINARS	WORKSHOP	ACADEMIA/EASA INNOVATION FAIR
Setting	on-line	on-line or in-person	Key notes, Panels of 4 to 6 speakers, flash talks, award ceremony
Objective	Sharing information, raising awareness, reaching conclusions	Sharing information, raising awareness, reaching conclusions	Networking opportunity, raising awareness for topical developments visibility for academia and EASA
Format	Presentations & round table discussions	Presentations plus Q&A	
Cadence	4 – 10 per year	3 - 4 per year	Every two or three years
Duration	60 - 90 min	2 - 3 hours	1 - 2 days
Selection of themes	Proposed by academia or EASA experts; reviewed and endorsed by SciComm	Proposed by academia or EASA experts; reviewed and endorsed by SciComm	Proposed by SciComm; reviewed and endorsed by EXCOM and EASA Executive Directors
Speakers	Proposed by academia or EASA; reviewed and endorsed by SciComm	Proposed by academia or EASA; reviewed and endorsed by SciComm	Proposed by academia or EASA; reviewed and endorsed by SciComm
Revenue-generation	No	No	To be decided
Target audience	Leading experts from academia and/or EASA; EASA middle management	Leading experts from academia and/or EASA; EASA middle management	Senior management

Workshop versus Webinar - The main differences

A workshop and a webinar are both educational or instructional sessions, but they differ primarily in their format, interactivity, and intended purpose. Here's a comparison:

Workshop

- **Format**: Workshops are traditionally in-person, though they can also be conducted online. They are interactive sessions where participants engage in hands-on activities or practice under the guidance of facilitators or instructors.
- **Interactivity**: High. Workshops are designed to be interactive, allowing participants to work on tasks, engage in group discussions, and receive immediate feedback from facilitators.
- **Purpose**: The main goal of a workshop is to develop practical skills, solve problems, or make progress on specific projects. They are often more focused on application than theory.
- **Duration**: Can vary widely but often take up a significant part of a day or multiple days, given the hands-on nature of the activities involved.

Webinar

- **Format**: Webinars are exclusively online sessions that participants can join remotely. They typically involve a presentation or lecture delivered by a speaker to an audience via a web conferencing tool.
- **Interactivity**: Variable, but generally lower than workshops. While webinars can include Q&A sessions, polls, and chats, the interaction between the presenter and the audience is usually less hands-on and more focused on information dissemination.
- **Purpose**: The primary aim is to provide information, updates, or training on a particular topic. They are more geared towards knowledge sharing and are often more theoretical.
- **Duration**: Usually shorter than workshops, ranging from an hour to a few hours.

In summary, workshops are more interactive and focused on project advancement through hands-on activities, typically requiring more time and sometimes physical presence. Webinars, on the other hand, are more about information sharing and learning in a lecture-style format, generally shorter and conducted online.

10 Supporting Material: Interpretation of EU AI Act Article 14 versus EASA AI Level 3B and beyond

Position Paper prepared by the EASA AI
Programme and supported by the AI Task
Force of the EASA Scientific Committee

- September 2024 -

Author: Guillaume Soudain, EASA

Article 108 of the EU AI Act mandates the European Union Aviation Safety Agency (EASA) to ensure the safety and compliance of AI systems in aviation through appropriate oversight and regulatory measures, taking into account the Chapter III Section 2 requirements from the EU AI Act for high-risk AI systems.

One of the most essential articles from Chapter III Section 2 is Article 14 which is related to Human oversight. This article introduces the fundamental notion of effective oversight of AI-based systems by natural persons.

Depending on the Level of AI (based on the EASA AI Concept Paper definitions) considered this paragraph may raise important challenges.

- For **Level 1 (Human assistance) and Level 2 AI (Human-AI teaming),** the presence of a Human who can oversee and override the AI-based system at any point in time, enables **direct compliance with the Article 14 expectations**.
- For **Level 3A AI (safeguarded advanced automation),** the presence of an end user in the loop of operations meets a large part of the requirements however there is a clear need to clarify the **modalities of an "effective oversight" under remote monitoring conditions**.
- Most importantly for this discussion, for **Level 3B AI systems**, the presence of a natural person in the loop of operations is not ensured directly. The anticipation by the aviation community of operations such as drones delivery in urban environment under U-space management pushes de-facto the interpretation of natural person oversight further. Therefore there is a need for setting the **allowable boundaries of a "delegation" of oversight to systems at operational time**, based on the pre-requisite of full development-time oversight as required in EASA AI guidance (link to Concept Paper).

In this respect this position paper attempts to give a direction that can orient the development of aviation regulatory requirements, acceptable means of compliance (AMC) and guidance material (GM) to ensure safe deployment of Level 3B AI, ensuring an operational oversight concept based on independent systems.

Analysis of the text from Article 14

Paragraph 1 of this Article 14 introduces the notion of "effective oversight [of High-Risk AI systems] by natural persons during the period in which they are in use". Several elements of this paragraph require further consideration:

- In the context of the EU AI Act, "natural persons" refers to human individuals, as opposed to legal persons such as corporations or other entities.
- "Effective" implies the need for requirements and guidance on the modalities of oversight. In EASA framework this is addressed through the 'Human Factors for AI' building-block, which

provides requirements on Operational Explainability, Human-AI teaming and modality of interaction.

- "During the period in which they are in use" implies during operations.

Paragraph 2 is considered to be fully addressed by requirements of Chapter III Section 2 of the EU AI Act, and consequently through EASA AI trustworthiness guidance as anticipated in the EASA AI Concept Paper and as finalised through Rulemaking (RMT.0742).

Paragraph 3 is considered to be the enabler for an 'delegated operational oversight concept' that is necessary to enable levels 3B operations:

- "Measures identified and built […] into the high-risk AI system by the provider" implies that Level 3B AI-based systems could **foresee built-in independent monitoring and supervision function, as an equivalent model (proxy) of a natural person oversight**.
- In addition, the statement "measures identified by the provider before placing the high-risk AI system on the market or putting it into service and that are appropriate to be implemented by the deployer" is considered as directed at procedures for human end user oversight. It is therefore not applicable to Level 3B AI, as there is by definition no end user in the loop of such operations.
- This paragraph highlights the importance of "measures commensurate to the risks, level of autonomy and context of use of the high-risk AI system". In this respect the notion of "level of autonomy" should be understood as "level of automation", as "autonomy" is by definition contradicting the notion of oversight.

Paragraph 4 is understood as putting emphasis on specific technical circumstances without prescribing the "appropriateness and proportionality" of those. This paragraph is not considered sizing from the perspective of the discussion on Level 3B AI.

Paragraph 5 is specific to high-risk AI systems referred to in point 1(a) of Annex III of the EU AI Act, and as such not considered relevant to the scope of this discussion on Level 3B AI-based systems oversight.

Interpretation of Article 14 and way forward for Level 3B operations

Level 3B AI systems (non-supervised advanced automation) could be operated and effectively overseen thanks to introducing a model emulating natural person oversight. Indeed operational oversight could be carried out by independent monitoring and supervision systems that continuously evaluate the AI-based system's performance and safety.

These monitoring and supervision systems would interact with the AI-based system to detect anomalies and intervene when necessary, ensuring a balanced approach that maintains/emulates human judgment while enabling automated performance and safety monitoring.

Important is to remind that the design of the AI-based system (including the monitoring and supervision model) involves full oversight at development time by natural persons, ensuring that all systems are designed, validated and tested in compliance with the applicable ethical and regulatory framework.

Therefore EASA interprets paragraph 3 of the Article 14 in the EU AI Act as enabling built-in independent monitoring and supervision function, as an equivalent model (proxy) of a natural person oversight.

Conclusion and perspective

The presented argumentation thus opens a possibility to create a 'delegated operational oversight concept' to enable Level 3B AI operations (e.g. automatic drones operations and associated airspace management) compliant with the whole Article 14.

EASA seeks EU commission endorsement of this position paper to enable the development of this 'delegated operational oversight concept' in Issue 03 of the EASA AI Concept Paper.

11 Supporting Material: Analysis of ALFUS Framework with Emphasis on Mission and Environmental Aspects

Author: Prof. Marianna Jacyna, Warsaw University of Technology

Content

Analysis of the ALFUS Documents Focusing on Mission and Environmental Complexity

- NIST Criteria for Mission and Environmental Complexity
- Actionability of the NIST Criteria for Mission and Environmental Complexity

Basic documents

- Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume I: Terminology Version 2.0 - Oct. 2008.
- Autonomy Levels For Unmanned Systems (ALFUS) FRAMEWORK Volume II: Framework Models Version 1.0 December 2007.
- Autonomy Levels For Unmanned Systems (ALFUS) – the presentation by Hui-Min Huang/NIST.
- Hui-Min Huang, Kerry Pavek, James Albus, Elena Messina, 2005, Autonomy Levels for Unmanned Systems (ALFUS) Framework: An Update/ SPIE Defense and Security Symposium, Orlando, Florida.
- Hui-Min Huang, Autonomy levels for unmanned systems (ALFUS) framework: safety and application issues, PerMIS '07: Proceedings of the 2007 Workshop on Performance Metrics for Intelligent Systems. Pages 48 – 53.

Introduction

The Autonomy Levels for Unmanned Systems (ALFUS) framework, developed by the National Institute of Standards and Technology (NIST), provides a comprehensive methodology for evaluating the autonomy of unmanned systems. This report outlines the key features of the ALFUS evaluation process, focusing on mission and environmental complexities as critical dimensions. It further explores the applicability of ALFUS in specific domains, such as aviation, and suggests improvements to enhance its utility and relevance.

The ALFUS framework evaluates unmanned systems across two critical dimensions:

1. Contextual Autonomous Capability (CAC) to assesses the system's adaptability and capability in diverse operational contexts.
2. Level of Autonomy (LOA) to measure the degree of independence the system can achieve while performing tasks.

These dimensions incorporate detailed metrics for mission and environmental complexities, allowing a structured evaluation of system capabilities. The framework's foundational documents, including presentations and papers by Hui-Min Huang and colleagues, provide a basis for this analysis.

The ALFUS framework evaluates autonomy based on three primary dimensions: MC – Mission Complexity, EC – Environmental Complexity, HI – Human Independence (see Figure zz).

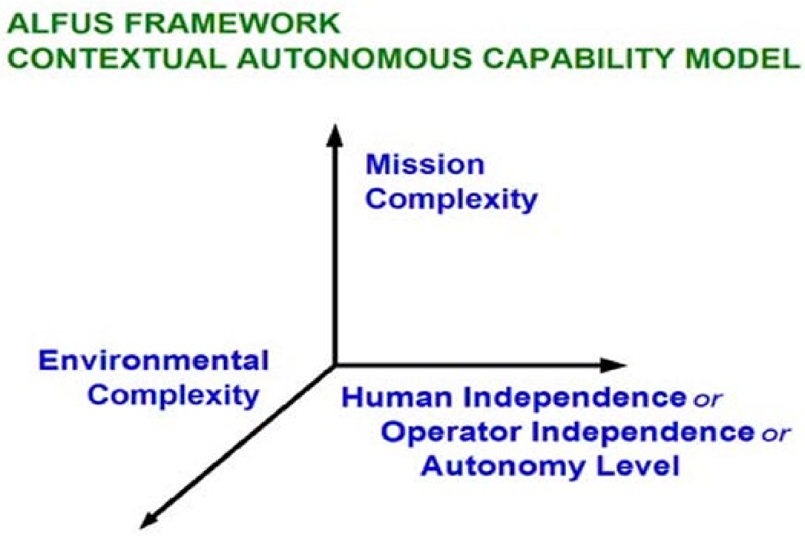


Figure ZZ: NIST ALFUS framework for contextual autonomous capability model

Source: based on autonomy levels for unmanned systems (ALFUS) – the presentation by Hui-Min Huang/NIST

Three levels of situational awareness are distinguished: **level 1** - perception, **level 2 -** comprehension, and **level 3** - projection. Situation awareness is defined with respect to the mission intent and environmental understanding.

Mission Complexity Metrics

MC evaluates the system's ability to perform tasks requiring high precision and adaptability. It revolves around tasks, subtasks, and decision-making within UMS operations. Key metrics include:

- Task Decomposition - the breakdown of missions into subtasks, collaboration levels, and decision-making requirements.
- Task Nature - considerations of risk, safety levels, and dynamic planning capabilities.
- Knowledge Requirements - the availability and uncertainty of information, as well as the system's ability to analyse cost-benefit and risk factors.

Challenges for MC analyse lay in:

- Subjectivity - task decomposition and metric prioritization are often subjective, leading to inconsistencies.
- Lack of Guidelines - there are no standardized procedures for task decomposition or interdependency management, affecting the consistency of evaluations.

To address these challenges, the framework needs:

- Standardized guidelines for task decomposition and metric weighting.
- Refined tools for managing task interdependencies.
- Integration of AI-driven algorithms to enhance mission planning and decision-making.

Environmental Complexity Metrics

EC examines the external factors affecting the system's operation. It includes:

- Dynamic Nature - environmental changes and their impact on operational effectiveness.

- Hazards - threats such as chemical, biological, and physical risks.
- Terrain and Infrastructure - variations in terrain, engineered structures, and meteorological conditions.

Challenges for EC analyses lay in:

- Dynamic Environments - the evaluation of rapidly changing environments, such as urban areas with moving obstacles, is underdeveloped.
- Subjectivity - interpretation of environmental metrics remains subjective, causing inconsistencies.

To improve environmental complexity evaluations:

- Define thresholds for environmental conditions, such as terrain gradients or urban density levels.
- Standardize scoring methods for dynamic factors, including weather changes and moving obstacles.
- Incorporate advanced methods for evaluating rapidly changing environments.

Limitations of the NIST ALFUS Criteria

The ALFUS framework has several limitations:

1. Subjectivity - the reliance on user interpretation risks inconsistencies in evaluations.
2. Weighting Issues - there is no standardized method for prioritizing metrics.
3. Scalability - evaluations become increasingly complex with larger systems and environments.
4. Lack of AI Integration - the framework does not account for advancements in AI technologies.

To address these challenges some recommendations for improvement must be proposed:

- Address subjectivity by standardizing evaluation guidelines.
- Develop scalable methodologies for handling complex environments.
- Integrate AI algorithms to enhance system performance and decision-making.

Aviation-Specific Adaptations

The ALFUS framework's adaptability to aviation highlights unique challenges and opportunities:

1. Environmental Criteria - metrics should include airspace congestion, weather conditions, and altitude-specific challenges.
2. Mission Complexity - flight tasks, such as takeoff, in-flight navigation, and landing, must be integrated into mission complexity metrics.
3. Regulatory Alignment - aligning the framework with aviation standards is essential for widespread adoption.

In aviation, mission and environmental complexities are crucial due to their direct impact on flight safety and efficiency. Mission complexity requires robust task decomposition and precision in planning, while environmental complexity must account for dynamic factors like meteorological conditions.

Recommendations for Framework Enhancement

To enhance the ALFUS framework's relevance and applicability:

1. Customization of Environmental Criteria - air transport involves unique environmental challenges such as airspace congestion, weather conditions, and altitude-specific issues. The environmental difficulty metrics must be expanded to accommodate these aviation-specific factors.

2. Adaptation of Mission Complexity - flight missions, which include navigation, communication, and real-time decision-making, need to be incorporated into the mission complexity metrics. The decomposition of flight tasks, such as takeoff, in-flight navigation, and landing, must be modeled within the ALFUS framework.
3. Certification and Regulation Alignment - integrating ALFUS with aviation regulatory standards is essential for acceptance in air transport. Developed two dimensions/levels by National Institute of Standards and Technology in the context of Unmanned Systems can be implemented in aviation. These levels take into account important elements, i.e. planning aspects in the level of mission complexity and take into account the influence of the surroundings/environment in the level of environmental complexity.
4. In aviation, environmental factors are extremely important which can be defined in the level of Environmental Complexity.
5. In the level of Mission Complexity, AI algorithms used in decision making problems must be developed.

Conclusion

The NIST ALFUS framework offers a robust foundation for evaluating UMS autonomy, with mission and environmental complexity dimensions providing critical insights. However, enhancements in standardization, quantification, and AI integration are essential to fully realize its potential. The ALFUS framework effectiveness is limited by subjectivity, scalability challenges, and the lack of AI integration. By tailoring these criteria to domain-specific needs, such as aviation, the framework can effectively support the development and deployment of autonomous systems in dynamic and high-stakes environments.

The integration of mission and environmental complexities into the framework ensures a comprehensive evaluation, allowing unmanned systems to achieve higher autonomy levels while maintaining safety and efficiency. Adopting these improvements will make ALFUS a valuable asset in advancing autonomous systems across various industries.