Haiku

AI IN AVIATION

Highlights

The HAIKU viewpoint

Funded by Horizon Europe R&I Program

Haiku
Human AI teaming Knowledge and Understanding for aviation safety

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Highlights

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“WHAT HAVE WE LEARNED ABOUT HUMAN-AI TEAMING FROM THE SIX AI AVIATION USE CASES?”

WHAT HAVE WE LEARNED ABOUT HUMAN-AI TEAMING FROM THE SIX AI AVIATION USE CASES?

Artificial Intelligence (AI) is a powerful technology that **aviation personnel** can effectively and safely collaborate with in the near future.
The target areas for its application include both **complex high-workload scenarios** (to support and enhance human decision-making) and **routine operations** (to assist in repetitive tasks), perhaps starting with the latter type of application as a strategy to ease AI acceptance.
Overall, what really matters is the **tangible value** provided by the AI solution, avoiding adoption “driven by hype”. AI solutions and the related Human-AI Teaming (HAT) concepts should be designed in a way that preserves - or even creates new - **meaningful human roles**. AI should convey a **sense of control and awareness** desired by the human end users, with AI either supporting or acting but **not overriding end-users’ intentions and decisions**. Appropriate **regulations** will be key to avoid undesired usage and unsafe outcomes.

The **main recommendations concerning HAT** fresulting from the use cases are as follows:

HUMAN-CENTRED DESIGN

AI solutions should be developed around **human needs**, with problem framing before algorithm development, and **end-user involvement** in all design stages. How to do so?

a. **User needs definition, in three stands:** Human needs and motivations relevant to the baseline CONOPS, key operational opportunities and pain points, and potential AI-driven enhancements. This needs to be developed for all stakeholders - analysing different perspectives and preferences - to ensure that the AI solution can address the full scope of operations.
b. **CONOPS definition:** Clearly define the concrete operational value Human-AI teaming could bring to the CONOPS compared to traditional automation.
c. **Human-AI Teaming definition:** Define clear boundaries, roles, responsibilities and interaction modalities between the human and the AI system in the operational context, specifying AI limitations.
d. **Concept specification:** Refine the concepts on the basis of regulation in an iterative way e.g. using the EASA Guidance framework as a foundation for assurance that technological systems adequately support human needs and maximize overall system performance. Define clear task allocation between humans and AI and extend the list of design and performance requirements to align with the regulation.
e. **Development:** Co-develop the solution step-by-step with users in representative scenarios, including different operational explainability (XAI) solutions to find the most suitable one for the specific application. Deliver robust support to humans according to the assigned roles, tasks and responsibilities. Run iterative validation activities, *e.g. go back to [c] to refine the HAT, and [d] to complete the concept specification.*

SKILLS DEFINITION & CRM/TRM TRAINING

In parallel to the design phase and before planning the deployment of an AI-based system:

a. Provide **AI literacy training**[1] (its potential, benefits and limitations) to all stakeholders to build understanding and trust, paving the way for its acceptance.
b. Analyse its **impact on** end-users' **competencies and skills**, adapting selection and training strategies accordingly.
c. Prepare for the shift from CRM/TRM to **AI-CRM/TRM training** where the concept of effective teamworking is extended to include Human-AI co-working.

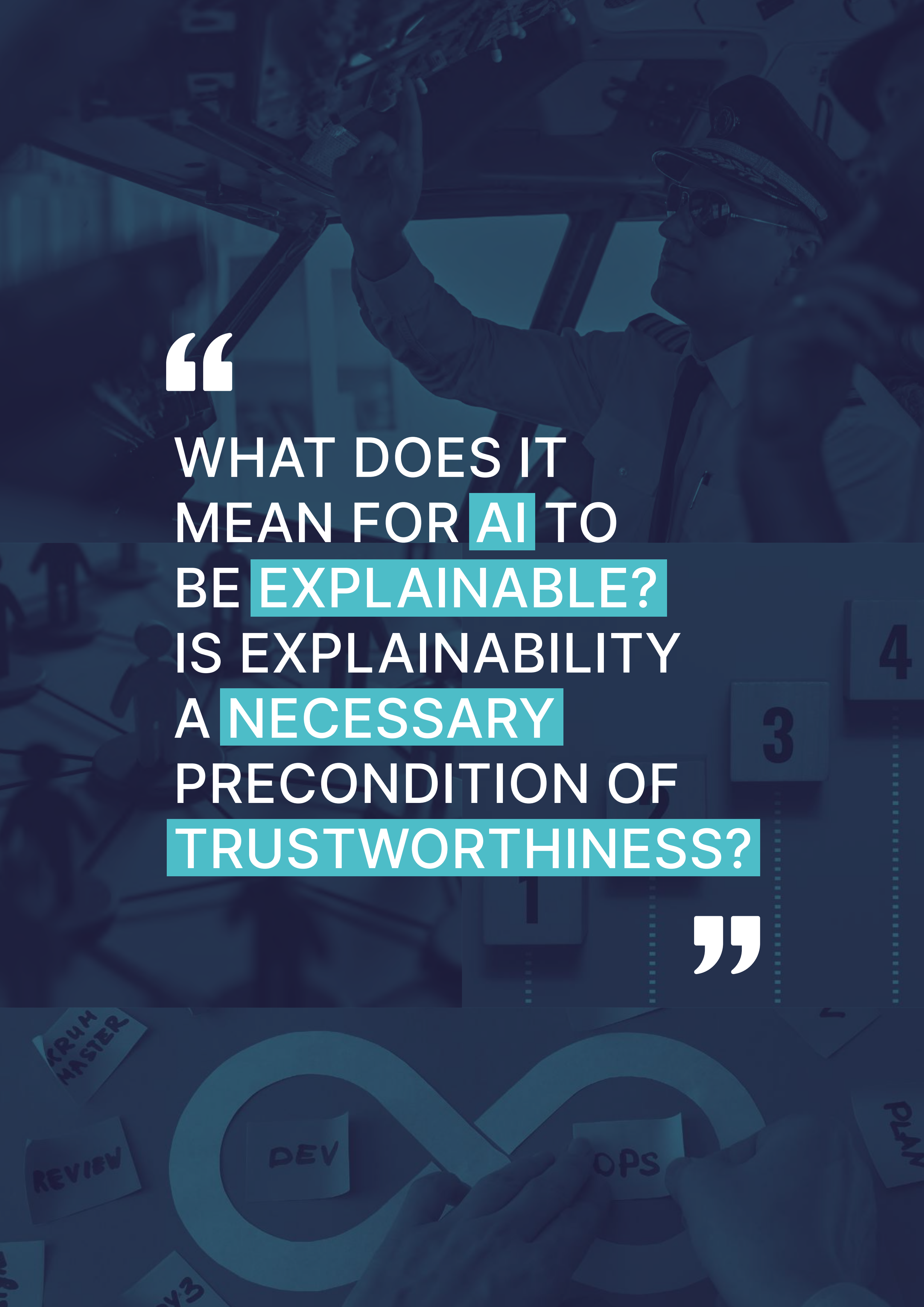
GRADUAL DEPLOYMENT

AI solutions should be deployed gradually - planning different releases - to ensure understanding, give time to develop trust and acceptance, and let the Human-AI team co-evolve[2] into optimal performance. There is no single approach suitable for all AI applications; the pace of deployment varies from situation to situation. How to do so?

a. **Ensure reliability of the system and HAT** associated with it, with performance monitoring and testing of off-nominal conditions, and definition of clear acceptable boundaries of performance.
b. **Introduce AI in controlled stages:** from simulations to operational environments. Start with low-traffic environments in ATM before full operational use, wherever possible and suitable. Consider the possibility of running the new AI system in 'shadow mode, in parallel with the previous system (if existing).
c. After deployment **monitor the evolution of the human-AI partnership**, keeping a focus on joint human-AI performance.

Looking further ahead, the aviation industry may consider developing **personalized solutions**, assessing benefits but also the potential risks for a highly standardised and proceduralised industry. What could be the boundaries of this type of application to ensure its effective and safe usage in such a safety-critical industry? This is a challenging perspective that still needs to be explored by future research studies.

[1] EU AI Act (Article 4: AI literacy).
[2] In aviation, as of today, this co-evolution can only occur during the design phase, not in operational settings, where feedback from operations are key to enable progressive design improvements.



> WHAT DOES IT MEAN FOR **AI** TO BE **EXPLAINABLE?** IS EXPLAINABILITY A **NECESSARY** PRECONDITION OF **TRUSTWORTHINESS?**

WHAT DOES IT MEAN FOR AI TO BE EXPLAINABLE? IS EXPLAINABILITY A NECESSARY PRECONDITION OF TRUSTWORTHINESS?

When approaching AI-based solutions, aviation end-users primarily want something that works and works well for them. They also want to have a **sufficient understanding** of the AI-based system to know they are in control of the situation, because they are responsible for flight crew and passenger safety.

There are three ways to build sufficient understanding of AI-based system functionalities:

a. **Beforehand** via **training** (general on AI basics and system-specific);
b. **During operations** with context-based **explainability**;
c. **After** training/operations during **debriefing** to explore what happened and why, and to consider what-if scenarios (i.e. what could have happened).

Training is an appropriate means for all contexts, while the usefulness of explainability during operations depends on the case and tends not to be suitable for time-critical situations. Indeed, the first step to design Explainable-AI (XAI) is to find the right balance between the need for real-time understanding of what AI is doing and the time required to go through and digest the information.

In HAIKU, AI is considered explainable when its explanations resonate with those of the end users, meaning its internal model aligns with the human's mental model. A set **of key recommendations to design XAI systems** are provided below:

USER-DRIVEN XAI

Explainability should target **different user groups distinctly** (operational users, supervisors, post-ops users, developers, and designers), deriving **tailored sets of XAI requirements.**

STRUCTURED EXPLAINABILITY LEVELS

XAI should provide appropriate **levels of explanation** at the right time and in the right place to the right user. To keep a coherent approach, HAIKU has adopted a XAI framework derived from **Construal Level Theory (CLT)** *(Construal Level Theory for designing operational explainability for Human-AI Teaming interfaces in aviation contexts,. Venditti, R. et al., 2025)*, where the quantity of information and the time required to process it drive the XAI design choices. Conceive explainability as a **dynamic concept** as XAI needs may decrease as user familiarity and trust increases.

ITERATIVE XAI DESIGN

XAI should be the result of a **constant dialogue between AI developers and operational users** through iterative developments, exploring different design alternatives.

An interesting avenue for future research studies, not explored in HAIKU, is the concept of **XAI as a dialogue process** where a human seeking understanding can query the system until fully satisfied.

"HOW TO TRAIN AI TO ASSIST HUMANS IN SAFETY CRITICAL TASKS WHEN TRAINING DATA ARE INSUFFICIENT?"

HOW TO TRAIN AI TO ASSIST HUMANS IN SAFETY CRITICAL TASKS WHEN TRAINING DATA ARE INSUFFICIENT?

Data availability is a crucial asset for the development of AI-systems. As early as possible, it is essential to conduct a **preliminary feasibility assessment** by addressing the following key question: *Given the available data, can the AI model be adequately trained? This question does not have a simple black-and-white answer, as it varies from situation to situation.*

To help navigate this critical aspect, the **following insights** are provided below:

LOOK BEYOND DATA ASSOCIATED WITH NEGATIVE EVENTS

There is a tendency to focus AI training on data related to events that should be avoided. Fortunately, such cases are relatively rare in the aviation industry. However, this means data scarcity for AI aviation applications. To address this challenge, it is important to consider that AI can also **learn from data associated with positive outcomes**. While this approach increases complexity and requires resources - i.e. effort intensive labelling - it can be a way to expand the training set.

CONSIDER DATA AUGMENTATION STRATEGIES

Expanding the training dataset through **synthetic data generation** or **simulated environments** is currently being explored. It is a research avenue worthy of further investigation, as it may have the potential to enhance model performance and robustness.

ADAPT AI'S ROLE BASED ON DATA AVAILABILITY

When targeting **safety-critical tasks**, and finding that data are insufficient, caution is required. In such cases, prioritising the use of **AI to support processes and data analysis**, rather than AI making decisions or suggesting options, can be a valuable solution. Creativity and final decisions should rest in human hands, and **alternative techniques**, such as rule-based algorithms, can be considered for this type of support.

DON'T GET "CAUGHT UP IN THE HYPE"

Use AI only if you can train it with the right data and ensure real added value; otherwise, **seek alternative solutions**.

Overall, when developing an AI-based system, design with the understanding that unknowns will always exist for both humans and AI. Therefore, the Human-AI system should embrace a **dynamic approach based on the principle of constant co-evolution**, with humans and AI trained to recognise when they are treading in unexplored situations.

“WHAT IS THE POTENTIAL IMPACT OF AI ON SAFETY CULTURE?”

WHAT IS THE POTENTIAL IMPACT OF AI ON SAFETY CULTURE?

The pilots' point of view

*AI might have a **positive impact on Safety Culture**, but only if **properly regulated** to avoid undesired usage and unsafe outcomes.*

WHAT PILOTS WOULD SAY TO...

MANUFACTURERS

"I don't care whether it's AI or advanced automation - what matters is that it gives me a true **sense of control**."

"AI is a powerful technology that I would welcome on board, but only if it **does not override my intentions and decisions** and **can be switched off** whenever necessary."

"When designing an AI-based system, don't start from the assumption that *"pilots always do things right"*. Instead, focus on ensuring that **humans operate as they are supposed to.**"

AI EXPERTS

"Can AI really be **trained on Safety Culture**?"

"**Active monitoring** is a cornerstone of safety culture. As Pilot Monitoring I wonder: how to perform it safely when AI becomes another "crew member" to oversee and cross-check actions with?"

"AI may be a valuable support to prevent and detect **human errors**, supporting in recovery. But will it be also capable of helping me in preventing, detecting and recovering from its own errors?"

WHAT IS THE POTENTIAL IMPACT OF AI ON SAFETY CULTURE?

The pilots' point of view

Pilots' **openness to adopting AI onboard** *may depend on the aircraft they are used to flying. Those accustomed to highly automated systems are likely to be more inclined to embrace it.*

WHAT PILOTS WOULD SAY TO...

AIRLINE COMPANIES

"Don't ask me if I would feel safer with AI - It is impossible to say right now. Guide me towards its acceptance by **involving me in its design** and **introducing it gradually**, starting with AI solutions that handle the **tasks I find boring**."

"To enhance our understanding and start fostering AI acceptance, airlines should start **training us on AI literacy** today."

"I already **speak up for safety** today but not all pilots do it as reporting requires extra-time. I bet the introduction of AI could actually **help increase reporting**... though only if the added value of pilots' work continues to be sustained and recognised."

FUTURE PILOTS

"When AI will be in operation, current recurring training will no longer be sufficient to **retain technical skills**, which I feel increasingly becoming an **individual responsibility**."

“HOW CAN AI SUPPORT PILOTS IN EFFECTIVELY HANDLING STARTLING AND SURPRISING EVENT IN THE COCKPIT?”

USE CASE #1

HOW CAN AI SUPPORT PILOTS IN EFFECTIVELY HANDLING STARTLING AND SURPRISING EVENT IN THE COCKPIT?

THE FOCUS INTELLIGENT ASSISTANT (FLIGHT OPERATIONAL COMPANION FOR UNEXPECTED SITUATIONS)

SHORT DESCRIPTION

The FOCUS assistant aims to support pilots during startling and surprising events in the cockpit. These events sometimes provoke “freeze” reactions, delay in response time or inappropriate cockpit inputs and can lead to accidents.
To tackle this, FOCUS helps pilots in managing Stress and regain Situational Awareness. It offers real-time assistance, detecting startling events and aiding in quick recovery from complex situations.

Promotional video **Demo video**

CLASSIFICATION

EASA Level 2A: Human and AI-based system cooperation
FOCUS shows how AI augmentation can complement human expertise, fostering a cooperative and trustworthy human-AI interaction. The pilot always remains in control and can easily activate or deactivate FOCUS whenever needed.

USE CASE #1 LEADER

ENAC

TRL

FOCUS is a complex agent composed of 3 main building blocks: (1) Startle detection function (2) Stress regulation support (3) Situation Awareness Augmentation. Most of them started from TRL1 and reached TRL4 at the end of the project.

SEP '22

- M1 — **TRL1:** CONOPS formulation
- M6 — **TRL2:** Prototype specifications definition (through end-users interviews and design meetings)
- M16 — **TRL3:** Prototype Version 1 Validation
  - Laboratory test for (1) (startle and surprise fundamental experiment)
  - Aircraft simulator test with end-users for (2) and (3) on first iteration of FOCUS
- M28 — **TRL4:** Prototype Version 2 Validation
  - AI Training with new datasets and testing with data collected in the simulator for (1)
  - Laboratory tests for (2) (vibrotactile experiment)
  - Aircraft simulator test with end-users in a relevant operational scenario for (2) and (3) for iteration two of FOCUS
- M36

AUG '25

RECOMMENDATIONS FROM HAIKU USE CASE #1 FOR FUTURE RESEARCH

1. **Balance operational explainability and Human-AI Teaming with available time:** due to time criticality together with the pilot's altered mental state, operational explainability emerges not to be an effective way to build trust and understanding in this Use Case.

2. **Explore different interaction modalities:** a transition to voice-based interactions could help reduce cognitive workload. As such, it is advisable to investigate this interaction modality as a potential approach for effectively incorporating operational explainability into this use case.

3. **Go beyond operational explainability:** don't overlook the potential of training as it emerges to be the most effective way to enable pilots' familiarisation with and understanding of the system in such a time-critical context.

4. **Explore solutions to align AI reasoning with that of the pilots:** incorporating decision-making frameworks (e.g. FORDEC) in the AI system is expected to improve Human-AI cooperation.

5. **Look into the realm of personalisation:** this has the potential to enhance Human-AI cooperation, with AI providing support to pilots considering specific flying patterns and preferences.

6. **Explore how AI and Human-AI Teaming can assist in managing startling and surprising events in a 2-pilots configuration:** HAIKU Use Case 1 focuses on one-to-one interactions, demonstrating how FOCUS can offer valuable support to a single-pilot. But how can this concept translate to a crew setting? This is a research question for further exploration.

“HOW CAN WE **LEVERAGE HISTORICAL DATA** TO GENERATE ACTIONABLE SAFETY INTELLIGENCE FOR IMPROVING DAY-TO-DAY **AIRPORT OPERATIONS** AND SAFETY PERFORMANCE?”

USE CASE #5

HOW CAN WE LEVERAGE HISTORICAL DATA TO GENERATE ACTIONABLE SAFETY INTELLIGENCE FOR IMPROVING DAY-TO-DAY AIRPORT OPERATIONS AND SAFETY PERFORMANCE?

THE AIRPORT SAFETY WATCH (ASW) INTELLIGENT ASSISTANT

SHORT DESCRIPTION

The Airport Safety Watch (ASW) assistant aims to enhance the daily safety of airport operations by using both historical and real-time data to minimise the risks of safety events and incidents on the airfield.
ASW assists the airport duty-holder (London Luton Airport - LLA) and other principal airport users, in reducing the risks of three key incident types: pushback error, hold-point busts and incorrect taxiway selection. ASW uses data science (AI) to determine causal and contributory factors, presenting insights in a multi-layered dashboard to drive actionable safety improvements and reduce risk.

Promotional video | **Demo video**

CLASSIFICATION

EASA Level 1A - Human augmentation
ASW provides enhanced information to airport safety personnel, augmenting their ability to identify actionable safety insights from complex data patterns.

USE CASE #5 TEAM

London Luton Airport, EUROCONTROL, ENGINEERING

TRL

The design of the ASW started from scratch and reached TRL9 at the end of the project.

SEP '22

- M1 — **TRL1:** CONOPS formulation
- M6 — **TRL1:** Basic principles definition
- M9 — **TRL2:** Application formulation
- M12 — **TRL3:** Proof-of-concept
- M15 — **TRL4:** Functional verification
- M19 — **TRL5:** Readboards (reduced scale) verification in relevant environment
- M23 — **TRL6:** Dashboard demo in LLA and Luton Safety Stuck
- M27 — **TRL7:** Dashboard testing in LLA systems
- M30 — **TRL8:** Dashboard in use for LLA airside safety officers briefing
- M36 — **TRL9:** Dashboard Integrated into LLA safety management infrastructure

AUG '25

RECOMMENDATIONS FROM HAIKU USE CASE #1 FOR FUTURE RESEARCH

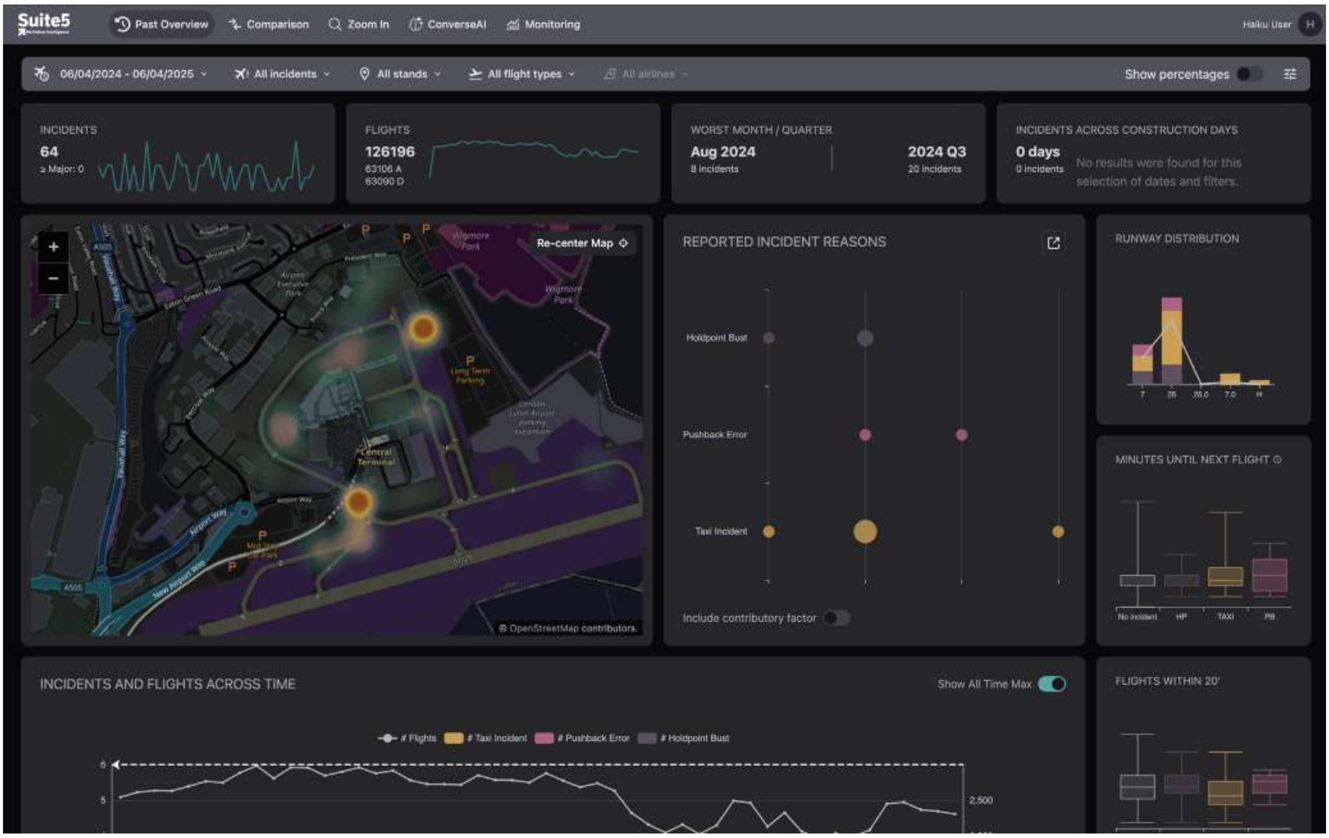
1. **Adopt a user-centric design approach:** going beyond primary users and involving a broad range of stakeholders throughout all stages of the ASW design proved essential in delivering a more effective and impactful solution.

2. **Go with a gradual deployment strategy:** this was a successful way to engage airport users in an effective co-constructive process, fostering trust and acceptance and allowing a seamless integration into LLA's safety management system.

3. **Strive to improve how risk intelligence can be used in day-to-day operations:** ASW has not only enhanced the efficiency of safety operations but also transformed the way safety people do their job and make decisions, and inform all airside users on day-to-day risks.

4. **Explore more advanced AI techniques when more data is available:** The application of more advanced AI techniques would enhance future incidents forecast and should be further explored, evaluating feasibility according to data availability.

5. **Explore applicability of ASW approach to other contexts:** HAIKU Use Case 5 focuses on London Luton Airport, a single-runway airport, demonstrating how AI and data visualisation can enhance airport safety by providing insights into past incidents and contributing to risk reduction. However, would this approach be effective for airports with different operational characteristics? This is a research question for further exploration.



HAIKU CONSORTIUM

We are **15 Partners** from 10 different countries, bringing together **Human Factors** expertise, domain's key **end-users** and **technology** suppliers of excellence.

END-USERS

ADVISOR

Haiku
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