Haiku
Human AI teaming Knowledge and Understanding for aviation safety

Deliverable N. 3.2

Concepts of Intelligent Assistants

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Abstract:

This deliverable documents the activities and the results achieved within HAIKU Task 3.4, “Concepts of Intelligent Assistants". It presents a set of 17 Intelligent Assistant (IA) concepts for the aviation domain, targeting all its segments: ATM, UAM, Cockpit and Airport segments.

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List of Acronyms

Acronym	Definition
A/C	Aircraft
ANSP	Air Navigation Service Provider
AOCC	Airport Operation Control Center
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
AR	Augmented Reality
EACCC	European Aviation Crisis Coordination Cell
FD	Flight Dispatcher
FMS	Flight Management System
FO	Foreign Object
IA	Intelligent Assistant
OCC	Operational Control Centre
OEM	Original Equipment Manufacturer
RWY	Runway
SA	Situational Awareness
SPO	Single Pilot Operations
TWR	Tower
UAM	Urban Air Mobility
UAS	Unmanned Aerial System
UI	User Interface
UX	User Experience

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Executive Summary

Deliverable 3.2 aims at producing a set of detailed Intelligent Assistant (IA), with the intention of inspiring the six HAIKU use cases, as well as shedding light on the most promising and desirable avenues for AI application in aviation.

The concepts were produced and refined in the context of Task 3.4 as a result of a series of segment-specific (ATM, UAM, Cockpit, Airport) co-design workshops. The final list of concepts consists of 17 total IAs divided into the four aviation segments of interest to the project. The developed concepts are the following:

Air Traffic Management concepts

1. Crisis Intelligence Portal
2. HIPS: Health Issues Prevention System
3. COPE: Controller Optimised Performance for the Environment
4. Greta
5. Airport Awareness System

Urban Air Mobility concepts

1. City Skywatch for Real-time Risk Assessment
2. SynchronAir
3. MaintenAI Digital Twin

Cockpit concepts

1. Fleet Master AI
2. FlightComm
3. Collaborative Cockpit Assistant
4. Personal Trainer AI
5. AI Inspector

Airport concepts

1. Multimodal Travel Planner
2. Airport Guard
3. RIDE: Rapid Integrated Digital Entry
4. Airport White Rabbit

The **Intelligent Assistant Concepts** section of this document details each IA in terms of use case, system's end users, user needs, tasks, the timing of usage, interaction modalities, benefits, and pain points. An example use case is also provided for each concept.

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1. Introduction

1.1. Scope and structure of the document

The main purpose of this document is to present the activities and results achieved within HAIKU Task 3.4, "Intelligent Assistant Concepts". The objective of Task 3.4 is to produce a set of Intelligent Assistant (IA) concepts, with the intention of inspiring, refining and streamlining the six HAIKU use cases.

The document is organised into the following chapters:

- Chapter 1 (the current one), explains the methodologies used to generate the IA concepts and the criteria behind the selection of 17 concepts.
- Chapter 2 shows the details of each IA concept in relation to the relevant aviation segment (ATM, UAM, Cockpit, Airport).
- Chapter 3 is the conclusion.

1.2. Methodology

The IA concepts were generated through four co-creation workshops, each focused on a specific aviation segment:

- Workshop 1, 14 participants: UATM (January 27th, virtual - FigJam platform).
- Workshop 2, 6 participants: ATM (February 2nd, Brussels).
- Workshop 3, 10 participants: Cockpit (February 13th, Rome).
- Workshop 4, 10 participants: Airport (February 13th, Rome).

The workshops consisted of three main activities that were repeated for both the online and in-person versions, with minor adjustments made to accommodate the online format. All the materials used for the workshops are in Annex A. The activities were:

1. **Imagine high-level concepts**: during this initial phase, participants were asked to individually fill out card templates with high-level ideas about IA concepts that could be relevant to the domain of interest. Participants were only required to provide the name of the assistant, its general objective, and a short description of the user who would benefit from it. Additionally, they were instructed not to focus on actual feasibility, implementation details, or viability. As this was a divergent activity, the focus was on generating as many ideas as possible without being constrained by practical considerations.

2. **Map Human-AI Teaming types**: participants were asked to assign labels to each idea generated during the first phase. These labels were created before the

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workshop and were used to define the role of the IA in different Human-AI teaming configurations. The labels, which were loosely inspired by Belbin's team roles (Belbin, 1981), were *Informer*, *Observer*, *Secretary*, *Coordinator*, *Rescuer, Executor*. The classification matrix for all the roles is shown in Figure 1.

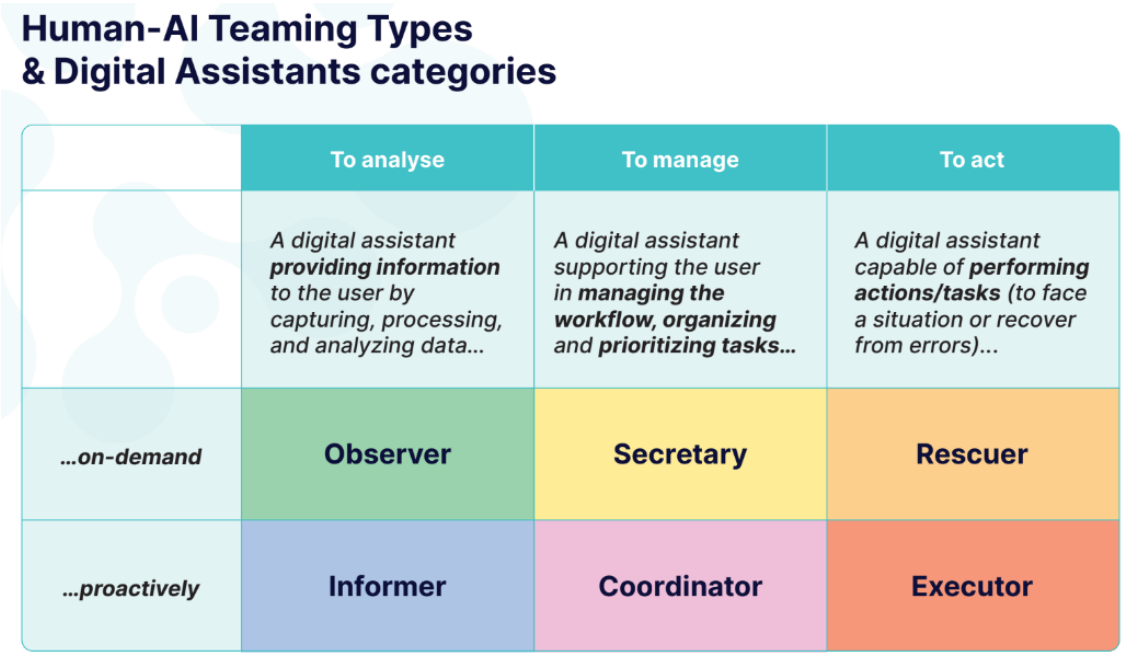

Figure 1: matrix with the different types of IA roles used in the workshop

3. **Define Concept descriptions**: participants were split into groups and asked to select the best ideas from the previous phases. They were then tasked with providing more detailed information about the chosen ideas, such as the user's tasks, interaction modalities, scenarios of applications, and any potential pain points or constraints. To do this, they were given grids to fill out with detailed information about each concept. The outcome of this final phase was a series of complete IA concepts.

1.3. Selection criteria

During the workshops numerous ideas were generated, and a selection process was carried out to choose the best ones and further develop them. The selection criteria were:

- **Human-centeredness:** looking ahead to 2030 and beyond, how well the selected concepts could address the targeted user's needs?

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- **Potential for application**: what are the most promising concepts for the future of aviation?
- **Innovativeness:** how innovative are the concepts from an operational, technological, and societal perspective?

The selected IA concepts then underwent a final review process before being fully elaborated into 17 fleshed-out concepts. Similar ideas were merged to create more robust concepts, while others were discarded. Annex B contains a list of other ideas that were not selected.

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2. Intelligent Assistant concepts

The 17 IA concepts are categorised into the segments of interest of the project:

- 5 IA concepts for ATM;
- 3 IA concepts for UAM;
- 5 IA concepts for Cockpit;
- 4 IA concepts for Airport.

The following paragraphs provide an overview of the users expected to interact with the IAs in each segment, an introduction to each IA concept, and a table presenting details about the system's end-users, their needs, tasks, usage time, interaction modalities, data utilised, benefits, and pain points. The expected Human-AI Teaming role (Informer/Observer, Secretary/Coordinator, Rescuer/Executor) is also indicated. Lastly, an example use case is included for each IA.

2.1. Air Traffic Management (ATM) concepts

The IAs presented in the Air Traffic Management (ATM) segment aim to improve the efficiency of operations related to all aspects of traffic management. They would form Human-AI teaming with the following actors:

- Air Traffic Controllers (ATCOs): ATCOs are responsible for managing the flow of air traffic in a safe and efficient manner.
- Air Traffic Flow Management Team: ATFM involves air traffic control agencies, airlines, airport operators, and other aviation stakeholders involved in the management and operation of air traffic.
- Decision-makers in the European Aviation Crisis Coordination Cell: Individuals making important traffic-related decisions during crises.
- Environmental authorities: Organisations that monitor fuel consumption and emissions from aircraft.

Given that the use of these IAs might lead to better management of air traffic, other actors that would be indirectly affected by them would be Air Navigation Service Providers (ANSPs), airlines and the general public.

IA Concept 1: Crisis Intelligence Portal

The Crisis Intelligence Portal (CIP) IA would be used by the European Aviation Crisis Coordination Cell to handle crisis events quickly and efficiently. The IA would select information and visualise from many sources to ensure that the decision-makers would have access to the most relevant information instantly. With this IA, the time for decision-making in critical situations should be significantly reduced, enabling more effective and optimised actions at the Network Management level.

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Crisis Intelligence Portal IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Decision-makers working in the European Aviation Crisis Coordination Cell (EACCC).
What **user needs** would the IA address?	Decision-makers need • A rapid assessment of available intelligence during network-wide crises. • To filter out irrelevant information and misinformation, such as fake news, to manage the crisis effectively. • To have an overview of the situation in case of multiple crises, which can be difficult for humans to manage effectively.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Advising European Network National Authorities during pan-European crises. • Providing timely and reliable information to support crisis coordination. • Filtering information from various sources, including social media, to ensure accuracy and relevance. • Monitoring the situation as it evolves and keeping decision-makers informed of any changes or developments.
When would the IA be used?	• During a crisis (e.g. pandemic, volcano eruption, nuclear war, Ebola outbreak, terrorist attacks etc.)
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Informer: this IA is expected to be able to inform users and provide organised and synthetic information about upcoming crises to facilitate decision-making, but will not take actions proactively.

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What **data** does the IA leverage?	External Data: this IA will leverage data coming from external sources of information. Examples could be social media, governmental platforms, and news agencies.
How would users **interact** with this IA?	Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Vocal, textual interaction: users can use voice and text to interact with the IA and demand information. Outputs of the system: • Visual stimuli: the IA should produce visualisations of data and facilitate information retrieval. • Auditory stimuli: the IA can produce acoustic alerts and sounds to divert attention to priority information.
What are the **main benefits** of this IA?	• Quicker and more accurate response. • Instant communication between parties involved in a crisis. • Overall faster resolution of crises.
What are the **main pain points** of this IA?	• In case the crisis involves two countries, it may be difficult to coordinate a solution. • It is challenging for AI to recognise fake or even vague, partial, incomplete or contradictory information. The process of filtering a massive amount of information may be computationally demanding.

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Crisis Intelligence Portal IA Use Case Example

A volcano in Northern Europe suddenly erupts, and European airports are forced to momentarily stop their operations. The Crisis Intelligence Portal (CIP) IA quickly gathers data from various sources, including satellite imagery, weather reports, and air traffic data. Using its advanced filtering algorithms, the IA identifies the most critical information and presents it to the European Aviation Crisis Coordination Cell. Within minutes, decision-makers can assess the situation and choose the best course of action, such as rerouting flights, diverting planes to alternative airports, or closing airspace. Thanks to the CIP IA, the crisis is handled quickly and efficiently, with minimal disruption to travellers and the aviation industry.

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IA Concept 2: HIPS: Health Issues Prevention System

The Health Issues Prevention System (HIPS) IA would be utilised in Control Towers (TWR) where only one ATCO is present. It would monitor the health status of the ATCO and promptly and automatically notify other network actors of any issues that arise, ranging from reduced vigilance to incapacitation.

HIPS IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • ATCO working solo • Any ATCO available in the network alerted by the IA. Secondary users (indirectly impacted by the IA): • ANSPs.
What **user needs** would the IA address?	ATCOs and ANSPs need • Support and contingency management in case of single ATCO reduced vigilance or incapacitation. • A way of immediately communicating with the ANSPs if something happens. • To activate a swift handover process when unfit to work.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring the health of the ATCO. • Predicting and detecting ATCO reduced vigilance and incapacitation. • Activating contingency/emergency procedures in case of single ATCO incapacitation.

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When would the IA be used?	The IA would constantly monitor ATCO's health. It will intervene only in case of detected health problems and reduced vigilance or incapacitation during operations.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Informer: this IA is expected to be able to monitor ATCOs' health and inform them if it notices dangerous patterns. In case of reduced vigilance, it will self-assess it with the ATCO before activating contingency procedures. In case of incapacitation, it will immediately switch to emergency mode, informing the on-call ATCO and their manager. Executor: this IA can activate contingency procedures and switch to emergency mode. In that case, besides informing the on-call ATCO, it will use Data Link messages to execute functions until necessary to ensure safe operations.
What **data** does the IA leverage?	Physiological Data: the IA will leverage the user's physiological data measured through sensors. Gaze tracking could also be leveraged to get additional information potentially relevant for monitoring ATCOs' vigilance.
How would users **interact** with this IA?	Users might interact with this IA via an interface connected to a series of cameras in the tower. Inputs to the system: • Vocal interaction: users can use voice to interact with the IA. • Physical button: an emergency button may be in the tower. Outputs of the system: • Visual stimuli: the IA should produce visualisations of data and facilitate information retrieval (e.g.: displaying health information).

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	• Auditory stimuli: the IA can produce sonification to attract attention to certain information. It can also automatically notify another ATCO to provide an update on the situation. • Haptic stimuli: if the IA detects that an ATCO is incapacitated, vibrotactile stimuli can be activated to see whether the ATCO responds.
What are the **main benefits** of this IA?	• Improved safety. • Cost-effectiveness (it allows having one single ATCO controlling on duty). • Operational effectiveness (it minimises interruptions and disruptions). • ATCOs' physiological status monitoring, ensuring higher well-being
What are the **main pain points** of this IA?	• The boundary between being considered unfit/fit to work may be unclear and may vary dramatically between individual ATCOs. • Potential intrusiveness of measurements and instruments. • Privacy concerns may lower ATCOs' acceptance. • Unions' acceptance. • Legal issues regarding ANSPs having access to individuals' health information (privacy concerns).

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Health Issues Prevention System IA Use Case Example

An ATCO is working alone in a TWR when he suddenly faints due to low blood pressure. The Health Issues Prevention System (HIPS) IA detects the ATCO's state of unconsciousness and immediately alerts the on-call ATCO and their manager, as well as the medical emergency service. Within seconds, the IA momentarily takes over and activates contingency procedures to handle the traffic while the on-call duty arrives and takes position. Thanks to the quick action of the HIPS IA and other network actors, the event is handled smoothly and with minimal disruption to air traffic.

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IA Concept 3: COPE: Controller Optimised Performance for the Environment

The Controller Optimised Performance for the Environment (COPE) IA would function as an all-knowing air traffic flow manager, active in the planning, pre-execution and execution phases. Aiming to optimise aviation performance from an environmental perspective, it would assist both human flow managers in planning the whole traffic flow, and ATCOs in handling real-time the flight paths of multiple aircraft by suggesting possible deviations and adjustments based on various types of data, including weather, environmental factors, airspace capacity, and traffic.

COPE IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Air Traffic Flow Manager Team; • ATCOs. Secondary users (indirectly impacted by the IA): • Airlines; • OCCs (Operational Control Centres).
What **user needs** would the IA address?	Air Traffic Flow Managers and ATCOs need • Support (in both planning and live operations) in identifying solutions for optimal trajectories for the environment while also finding compromises between all parties involved in operations. • Data-based support in identifying and tracking deviations from the optimal flight plan and flown route.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Planning traffic flow and flight plans; • Live detection of deviations between the flown route and the optimal flight plan introduced in the FMS.

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	• Identifying parameters (such as weather or environmental data) and using them to explain why deviations occurred. By doing so, it would be able to further optimise routes and flight plans. • Automatic real-time rerouting suggestions for all stakeholders. • Providing suggestions to improve the performance of certain A/C.
When would the IA be used?	The IA would always be active and used in both ATM planning and operations.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer: this IA is expected to observe, gather and process operational data. Secretary: The Air Traffic Flow Manager Team and ATCOs are expected to use the IA whenever necessary to receive on-demand suggestions.
What **data** does the IA leverage?	External Data: the IA will leverage external data sent by airlines and coming from the airspace. It will gather data about flight plans, traffic, environment, weather and aircraft performance, and all possible data that will be useful for its model to increase the decision-making capabilities.
How would users **interact** with this IA?	Users might interact with this IA via a dedicated interface. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Vocal, textual interaction: users can use voice or text to interact with the IA and demand information. Outputs of the system:

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	• Visual stimuli: the IA should produce visualisations of data to facilitate information retrieval, and generate graphics and text to suggest deviations.
What are the **main benefits** of this IA?	• Environmental: Lower carbon footprint. • Performance: optimisation of trajectories and reducing delays. • Human: ATCOs workload reduction. • Enhanced Safety.
What are the **main pain points** of this IA?	• It might be difficult to reach alignments between the optimal routes that ATCs are interested in, and airlines' goals.

COPE IA Use Case Example
During a major storm, the Controller Optimised Performance for the Environment (COPE) IA suggests flight path adjustments to minimise delays and reduce the impact of the disruption. By taking into account the overall traffic, weather and environmental factors, airspace capacity, stakeholders' priorities, aircraft types and performance, gate availability, etc., the IA helps to reroute flights to avoid the worst consequences of the storm and to adjust flight speeds to minimise fuel consumption and reduce emissions.

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IA Concept 4: Greta

The Greta IA would be used by environmental authorities to ensure that all aviation actors comply with regulations. It would be able to monitor fuel consumption and emissions for each flight, and then flag and report aircraft that exceed certain limits. Moreover, this IA would be able to automatically hand out fines and penalties based on objective data.

Greta IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Environmental authorities. Secondary users (indirectly impacted by the IA): • General Public (via Regulator Network Managers).
What **user needs** would the IA address?	Environmental authorities need • To identify organisations that don't comply with environmental regulations. • To make decisions based on factual and objective information.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring fuel consumption and emissions in real-time and the general environmental impact of each flight. • Automatically reporting the aircraft and proposing penalties and fines to authorities. • Creating evidence packages which can be assessed to determine post-fact fines.

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When would the IA be used?	The IA would always be active and used as direct support to environmental authorities.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Executor: this IA is expected to identify non-complying aircraft and proactively hand out fines.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from the airspace. It will gather data about each A/C to monitor its emissions and fuel usage.
How would users **interact** with this IA?	Users might interact with this IA via a dedicated interface. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). Outputs of the system: • Visual stimuli: the IA should produce visualisations of data to facilitate information retrieval, and generate graphics and text related to the evidence package for each specific use case.
What are the **main benefits** of this IA?	• Greener aviation. • Fairness in relation to what other transport modes are doing to safeguard the environment.
What are the **main pain points** of this IA?	• Airspace user acceptance. • Difficulties in finding an agreement on criteria for penalty scheme.

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	• Litigation Issues. • The model might be too rigid to consider procedures such as fuel dumping, or legitimate emergencies which may lead to higher fuel consumption than expected.

Greta IA Use Case Example
A commercial aircraft has exceeded its fuel consumption limits due to suboptimal flight planning. The IA quickly detects the issue and flags the aircraft, generating a report that is automatically sent to the appropriate authorities, and a penalty for the airline. Upon reviewing the report, the authorities determine that the airline is in violation of regulations and decide to confirm the fine provided by the IA. Thanks to the objective data provided by the Greta IA, there is no dispute about the violation, and the fine is quickly processed and handled.

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IA Concept 5: Airport Awareness System

The Airport Awareness System (AAS) IA would be used by ATCOs to monitor and coordinate all planned and unplanned activities related to the airport, including the movement of all vehicles and people on RWY, taxiway, and apron.

Airport Awareness System IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • TWR ATCOs.
What **user needs** would the IA address?	TWR ATCOs need • Support in monitoring and coordinating all airport activities with vehicles and people moving on the RWY, taxiway, and apron.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring and coordinating planned and unplanned (e.g.: FO inspections) airport activities on RWY, taxiway, and apron. • Monitoring and coordinating vehicles and people movements on RWY, Taxiway, and apron. • Monitor all A/C status (whether they are boarding, ready to push back, etc.) • Coordinating A/C movements for maintenance activities.
When would the IA be used?	The IA would always be active and used as direct support to TWR ATCOs.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Coordinator: this IA is expected to inform TWR ATCOs about movement in the airport, and help them coordinate their workflow to ensure that everything goes smoothly and safely.

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What **data** does the IA leverage?	External Data: the IA will leverage external data from cameras installed in the airport. The cameras should be able to correctly identify parts of the airport, vehicles and people.
How would users **interact** with this IA?	Users might interact with this IA via an interface in the TWR. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). Outputs of the system: • Visual stimuli: the IA should produce visualisations of data over-imposed on airport images to facilitate information retrieval and generate graphics and text to propose actions to the controllers. • Auditory stimuli: the IA should produce sonification when something unexpected happens (e.g.: a vehicle is on the runway when an A/C is about to descend) to immediately draw attention to a specific point of the airport.
What are the **main benefits** of this IA?	• Enhanced safety. • Increased efficiency. • Reduced workload. • Cost reduction (better monitoring and coordination lead to less risk of damages, fewer problems and cost savings)
What are the **main pain points** of this IA?	• If the system is not properly integrated into ATCOs' routines and takes, there may be acceptance problems, especially if the system will take over many tasks at once. • Privacy concerns (when cameras monitor

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	people). • Low visibility conditions might impact the IA performance.

Airport Awareness System Use Case Example
During a busy shift at an air traffic control tower, the Airport Awareness System (AAS) detects an object on the runway and recognises it as a luggage cart that must have fallen off a truck. The AI coordinates the actions to remove the object, predicting the time required for the ground personnel to remove it and suggesting the necessary actions to the TWR controllers. The controllers, on the basis of the suggestions provided by the IA, coordinate with ground personnel and adjust the sequence of aircraft to minimise disruption. The object is quickly removed and air traffic operations continue without delay.

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2.2. Urban Air Mobility (UAM) concepts

The IAs presented in the Urban Air Mobility (UAM) segment aim to facilitate the management of emerging UAM services. However, since the UAM concept is not yet consolidated, the specific actors expected to interact with the IAs are not yet defined. These envisaged actors may be:

- Individual UAS Operator: operates and maintains the individual UAS for UAM operations.
- UAM Coordinator: manages and coordinates UAM operations in a specific area or region.
- Fleet Managers: manages fleets of UAS.
- Network Managers: manages the overall UAM network (across more cities) by collaborating with all other actors involved.

IA Concept 1: City Skywatch for Real-time Risk Assessment

The City Skywatch Real-time Risk Assessment IA would help the UAM coordinator, fleet managers and individual UAS operators in monitoring and assessing safety risks related to operations. This IA would leverage data in real-time from various sources (data about population density, airspace and ground data, weather, historical data, and data strictly related to city life such as road traffic, events, emergencies, etc.) to identify potential risks that may threaten operations. It would then attract operators' attention to potential risks and suggest specific actions to prevent or efficiently handle them. In case of imminent risks, the City Skywatch would automatically activate contingency procedures. Ultimately, this IA wants to prevent and minimise risks, ensuring safer operations.

City Skywatch for Real-time Risk Assessment IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • UAM Coordinator. • Individual UAS Operators. • Fleet Managers. Secondary users (indirectly impacted by the IA): • City Managers. They might leverage the actions of this IA to plan multimodal travel integration in the city.

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What **user needs** would the IA address?	The primary users need • Support in planning individual missions, and during operation. • Ensure that the risk for UATM air vehicles, related passengers and third parties is minimised. • To meet operational and business constraints.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring what is happening in the city, and identifying and assessing risks and constraints for UAM operations. • Predicting risks by mixing real-time data with historical data and previous patterns. • Directing human attention to identified risks. • Applying conflict prevention strategies, such as suggesting the re-routing and optimal trajectory considering the risk in real-time based on live data about air traffic density and ground situation. • Applying contingency in case of imminent risks, such as hovering, diverting or landing for certain aircraft. • Creating a risk database that human operators can contribute to by adding information and further insight to allow the IA to learn and evolve.
When would the IA be used?	• The IA would be active 24/7, as the environment should be constantly monitored. • However, it would come in particularly handy every time risk is a factor (e.g. ground risk: the presence of people or

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	critical infrastructure/air risk: air traffic density).
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Informer: this IA is expected to inform and alert the UAM Coordinator when a risk is detected. Rescuer: this IA may propose actions to prevent risks estimated by mixing real-time data with historical data and previous patterns. Executor: In case of imminent risks, this IA might automatically activate contingency procedures (instructing an aircraft to land, for example).
What **data** does the IA leverage?	External Data: the IA will leverage external data (about airspace, weather, population density, historical data, as well as data related to city life such as road traffic, events, emergencies, etc.).However, users should also be able to input data themselves.
How would users **interact** with this IA?	Users might interact with this IA via a user interface in the control centre. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Textual interaction: users can input data via text to create new risks for the IA to store in the database. Outputs of the system: • Visual stimuli: the IA should produce visualisations of data about the airspace to facilitate information retrieval and decision-making. • Auditory stimuli: the IA should use sonification to attract the operators' attention to critical situations.

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What are the **main benefits** of this IA?	• Assessing risk in real-time and ensuring that the level of risk will always be acceptable. • Safety enhancement. • Cost reduction: as the level of risk will always be acceptable, a significant decrease in organisational cost related to risk monitoring is expected.
What are the **main pain points** of this IA?	• UAM Coordinators' and operators' loss of skills and risk of impaired situation awareness. • Over-reliance. If the system fails, users might not be able to make the most appropriate decisions without its support. • Users' trust, especially when dealing with risky scenarios. Furthermore, the trust may further deteriorate in case of unpredictable and unknown situations which are not detected by the IA.

City Skywatch IA Use Case Example
Suddenly, an unexpected protest erupts in the city. The City Skywatch Real-time Risk Assessment IA detects an increase in population density in the area surrounding the centre of the city. It alerts the UAM coordinator, fleet managers, and individual UAS operators. It advises them to temporarily halt operations in the area or adjust their operations to avoid flying over crowded areas, ensuring safer operations. However, one UAS operator fails to receive the alert due to a temporary power outage. The UAS is about to fly above the crowded area near the stadium to carry out a delivery mission, but the City Skywatch intervenes and issues instructions for the aircraft to land at the nearest vertiport by deviating its trajectory. Finally, the UAM Coordinator is informed by the IA.

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IA Concept 2: SynchronAir (Airspace Director)

The SynchronAir IA would facilitate cooperation across the entire network of UAM operations. Network managers, UAM coordinators, fleet managers, and UAS individual operators would use this IA. The IA would manage flight plans and define trajectories ensuring that fleet and individual operators could satisfy customers' requests while keeping traffic levels within capacity limits, respecting restricted areas, and, thus, ensuring safe operations. It would then dynamically reconfigure the airspace and prioritise certain operations over others, minimising contingencies, and streamlining the management of complexities.

SynchronAir IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Network managers. • UAM Coordinator. • Fleet Manager. • Individual UAS operators.
What **user needs** would the IA address?	The primary users need • Assistance in the complexity management of operations. • Coordination with other stakeholders. • Support in managing contingencies effectively and efficiently.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Gathering data from all airspace users and other sources (e.g. city authority warnings) for traffic planning, defining restricted areas, and managing capacity. • Reconfiguring airspace dynamically. • Coordinating all the system elements: ensuring that fleet and individual operators can organise missions. It should

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	be capable of satisfying customers' requests while keeping traffic levels within capacity limits, respecting restricted areas, and, thus, ensuring safe operations. • Managing contingencies and establishing priorities among operators. • Relaying information from one actor to another. • Giving clearances. • Identifying violations. • Attracting UAM Coordinator's attention to any kind of abnormal situations.
When would the IA be used?	The IA would be active every time there are operations in the city sky.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Coordinator: this IA is expected to coordinate the operations in the city sky. Executor: this IA is expected to automatically take actions and ensure that the overall system elements are coordinated.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from ground information on traffic, events, and authority warnings, whether from diverse data sources or unique data streams. Also, the IA would be able to use data input by users themselves.
How would users **interact** with this IA?	Users might interact with this IA via an interface in the control centre. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen).

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	Outputs of the system: • Visual stimuli: the IA should produce visualisations of data about the airspace to facilitate information retrieval and decision-making. • Auditory stimuli: the IA should use sonification to attract the operators' attention to critical situations.
What are the **main benefits** of this IA?	• It would allow maintaining traffic within capacity limits in all circumstances. • Prompt intervention in case of contingencies and emergencies, avoiding relevant disruptions. • Reduced cost for all airspace users
What are the **main pain points** of this IA?	• Over-reliance on the system. • Ensuring resilience and robustness. • Cybersecurity threats. • Time criticality of operations. • The operator's situational awareness in case of emergencies might be degraded. • Impact on safety level in case of malfunctions.

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SynchronAir IA Use Case Example

A building suddenly collapses in the centre of the city and many people require urgent medical assistance. In the midst of this emergency situation, a medical drone needs to pass through an already congested area filled with vehicles. The SynchronAir IA detects the emergency and promptly assigns priority to the medical drone. Also, it automatically issues geofences and sends instructions to the drones with the goal of diverting them to alternate routes to clear the way for the medical drone. Additionally, the IA sends alerts to all UAM operators in the affected area, notifying them of the emergency drone's priority status and providing them with instructions to follow the new flight paths.

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IA Concept 3: MaintenAI Digital Twin

The MaintenAI Digital Twin IA would be used by UAM operators to plan and schedule fleet maintenance according to Condition Based Maintenance paradigms. It would help in minimising downtime of systems, and slotting maintenance during the optimal moments. It would combine historical and live external data (from sensors) to predict the expected failure time of components, estimate the time needed for repairs, and plan them considering the operational needs of the system. Additionally, this IA should be able to suggest actions in case of unplanned emergency maintenance by considering historical data and current operating conditions.

MaintenAI Digital Twin IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • UAM operators. Secondary users (indirectly impacted by the IA): • Any other actor operating in the UAM ecosystem.
What **user needs** would the IA address?	The primary users need • To reduce downtime due to maintenance and maximising uptime of systems.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Optimising the maintenance schedule by considering the expected failure time of components, the time needed for repairs, and operational needs. • Suggesting the best course of action in case of unplanned emergency maintenance.
When would the IA be used?	This IA would be active every time there are operations in the city sky.

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What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer: this IA is expected to gather all information which could be accessed on-demand. Executor: this IA would also automatically schedule maintenance activities (both planned and emergency).
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from sensors to monitor each vehicle's health.
How would users **interact** with this IA?	Users might interact with this IA via a Digital Twin. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). Outputs of the system: • Visual stimuli: the IA should produce 3D models of vehicles with real-time data coming from the sensors.
What are the **main benefits** of this IA?	• Improved operational efficiency. • Improved safety. • Maintenance costs reduction.
What are the **main pain points** of this IA?	• Data from sensors may be unreliable in certain scenarios, and sensors might easily break.

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MaintenAI IA Use Case Example

As a drone is flying on a routine mission, dedicated onboard sensors detect abnormal vibrations in the motor that powers the propellers. The MaintenAI Digital Twin IA immediately receives the data and cross-references it with historical data and live external data to predict the expected failure time of the component and define the urgency of intervention. Then, it estimates the time needed for repairs and automatically schedules an extraordinary maintenance session during the optimal moment for the UAM network infrastructure, minimising downtime. It also cross-checks the availability of other vehicles as a temporary replacement, for example slightly postponing ordinary maintenance.

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2.3. Cockpit concepts

The IAs presented in the Cockpit segment mainly aim to improve the human performance of all operators involved. These IAs would form Human-AI teaming with the following actors:

- Single Pilots: Pilots who fly an aircraft alone, without a co-pilot or other crew members.
- Pilots in a traditional Configuration: Pilots who fly an aircraft as part of a traditional cockpit crew, typically consisting of two pilots.
- Flight Dispatchers: Flight Dispatchers are responsible for planning and coordinating flights, including developing flight plans, monitoring weather conditions, and ensuring compliance with safety regulations.
- Maintenance team: the maintenance team is responsible for ensuring that aircraft are properly maintained and serviced.

Other actors that would be indirectly affected by them would be airlines and ATCOs who would communicate with pilots.

IA Concept 1: Fleet Master

The Fleet Master is an IA designed to help airline companies manage their entire fleet and flight plans more efficiently. By capturing high-level stakeholders' intentions and considering all the relevant information and constraints, it assertively provides information to build a common understanding of the situation for both pilots and flight dispatchers, and proposes optimised solutions matching, as well as possible, all captured intentions. This IA supports FD for fleet decisions and pilots for flight decisions and ensures that the entire fleet is managed in a coordinated, user-centred, and cost-effective manner.

Fleet Master IA Summary	

Who are the end users?	Primary users (directly impacted by the IA):
	• Airlines. More specifically:
	  ○ Pilots.
	  ○ Flight Dispatchers.

What **user needs** would the IA address?	The primary users need • Optimised management of airline fleets and flight plans while also considering stakeholders' intentions (consisting of

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	safety, operational, and business considerations among others).
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Supporting FDs' and pilots' decision-making processing. • Advising fleet management. • Capturing high-level stakeholders' intentions (e.g. need for a more fuel-efficient path, preference for re-routing, or delay/cancellation etc..). • Providing means to efficiently share changes in context and full situation understanding between pilots and flight dispatchers. • Analysing all relevant information (delays, slots, gates and handlers availability, weather, etc..). • Proposing solutions to FDs to manage the whole fleet more efficiently, while also considering pilots' needs and intentions.
When would the IA be used?	This IA would be active all the time.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Coordinator: this IA is expected to support the FD plan and manage the fleet. It supports FD and pilots to achieve timely, good quality decisions to address changes in flight (e.g., due to traffic, airports, weather, etc), accommodating pilot intentions and needs. It would also proactively suggest actions and solutions.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from different sources (A/C, weather systems, network manager, airports, SWIM system).

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	Data input by users: the IA will also use data directly input by users (pilots).
How would users **interact** with this IA?	Users might interact with this IA via an integrated electronic flight bag, and a dedicated software interface embedded in the FD working position. Inputs to the system: • Vocal interaction, touchscreen interaction: the pilots would be able to communicate to the IA and express their intentions in natural language. Outputs of the system: • Visual stimuli: the IA should produce visualisations to show how the intentions have been used in the decision-making process. • Auditory stimuli: the IA should use sonification to notify users of new activities in the fleet.
What are the **main benefits** of this IA?	• Better disruption management during flights (e.g.: weather events). • Better integration of Cockpit, Airline Control Center and ATM. • As the capacity for cooperation/coordination increases across the system, an overall ATM flow improvement is expected. • Consideration of pilots' needs and intentions in day-by-day fleet management. • Reduced workload for FDs and pilots.
What are the **main pain points** of this IA?	• Difficulty in reaching a sufficient level of personalisation for pilots with different profiles.

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	• Ensuring the reliability of speech recognition, especially for pilots and dispatchers who may speak with different accents and voices. • Reliability of data. • End-users' acceptance. • Integration with network managers' operations and rules.

Fleet Master IA Use Case Example
Due to heavy rainfall, an airport has been closed, creating delays on a number of flights. The Fleet Master IA collects information on the weather situation in the concerned airport and in nearby ones, and asks crews, flight dispatchers and airport operators about their priorities. As a result, it sends advice to pilots and FDs on the best solution, e.g. diversion to alternate airports or delays. Crews can ask for different advice, suggesting to prioritise other criteria - e.g. fuel efficiency, crew time, and so on. The Fleet Manager IA handles the conversation in parallel until all the stakeholders are satisfied with the proposals. The ultimate goal of the IA is to ensure passenger safety and connections with minimal disruption to the airline's operations

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IA Concept 2: FlightComm

The FlightCom IA would help pilots in communicating effectively and efficiently with ATCOs by providing a single interface for all ATC interactions, independent of the sectors. All important communication (such as a change to flight plan) would be communicated instantly to relevant parties.

FlightCom IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Pilots. Secondary users (indirectly impacted by the IA): • ATCOs.
What **user needs** would the IA address?	The pilots need • Smooth and effective communication with ATCOs.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Transforming ATCOs' and AOCC's inputs coming by audio into two distinct audio interfaces which would interact with the pilot, always in the same different voice. • Automatically switch frequencies in the cockpit. • Communicating changes to the flight plan to all actors involved (and also ground/network services). • Ensuring there are no misunderstandings between the crew and air traffic services. • Preventing readback errors.

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When would the IA be used?	This IA would be active all the time.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Secretary: this IA is expected to be used on-demand by the crew whenever they wish to communicate with ATC. Informer: when a message arrives from ATC, the IA would be able to reproduce the incoming message. The system should also be able to detect misunderstandings from onboard pilots' readbacks and inform them. Executor: this IA is expected to automatically switch frequencies in the cockpit when passing from one sector to another one.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from ATM services and Airport Operation Control Center (AOCC).
How would users **interact** with this IA?	Users might interact with this IA via a software interface embedded in the cockpit and remotely connected to AOCC and ATC services. Inputs to the system: • Vocal interaction, textual interaction: the crew would be able to use voice and text to communicate directly with the IA, who would then relay the messages to the ATCs. Outputs of the system: • Visual stimuli: the IA should produce information visualisations to ensure that all the information in the communication channel is put across in a clear and digestible way. • Auditory stimuli: the IA should be able to synthesise speech and produce high-quality reproduction of communications.

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What are the **main benefits** of this IA?	• More efficient information retrieval for pilots. The right information at the right time, in the right format. • Reduced workload for pilots. • Reduced likelihood of human error due to communication inefficiencies (related to differences in languages, misunderstandings, etc.).
What are the **main pain points** of this IA?	• Accommodating the breadth of diversity of different languages, accents, and voices. • Responsibility sharing. • The synthetic ATCO Persona generated by the IA might not be able to display a series of emotions that would, however, be important when communicating with other human beings (i.e.: displaying empathy, showing stress and/or urgency when needed). • Need for human closeness (sometimes humans may want to talk to one another, and may want to bypass the synthetic ATCO).

FlightComm IA Use Case Example
On a long-haul flight from New York to Istanbul, an aircraft must navigate through several sectors and countries in Europe. As the flight progresses, the FlightComm IA ensures a smooth and uninterrupted ATCO experience for the crew, without requiring them to adapt to changing voices or regional nuances throughout the flight. This is particularly important during the descent phase, where the synthetic ATCO provides clear instructions and guidance in a seamless fashion.

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IA Concept 3: Collaborative Cockpit Assistant

The Collaborative Cockpit Assistant (CCA) IA would act as a full-fledged assistant for the Single Pilot. It would adapt to the pilot's personal traits, status, workflow and routines (by continuous learning), and would anticipate user needs and propose appropriate solutions in a wide array of different scenarios. It will especially be useful during emergencies when the pilot would need to maintain SA while simultaneously dealing with the problem at hand.

Collaborative Cockpit Assistant IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Single Pilot.
What **user needs** would the IA address?	Single Pilots need • To simplify workflows and prioritise activities. • To optimise the use of cognitive resources while maintaining situational awareness. • To assist in case of problems.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring aircraft systems (avionics, radio comms, ATM requests, on top of general flight condition and a/c trajectories). • Anticipating user needs. • Facilitating workflow. • Proposing prioritisations. • Detecting anomalies.

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	• Taking over to control the A/C in case of emergency.
When would the IA be used?	This IA would be active all the time.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer, Informer, Secretary, Coordinator, Rescuer: this IA would be like a real assistant: it is expected to be used on-demand, but it would also be able to interact proactively. Additionally, it is expected to take over the control of the A/C in case of emergencies.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from AOCC and ATM services. Contextual data: the IA will use data from aircraft systems and flight context. User's physiological measures: the IA needs to constantly monitor the physical (and possibly, mental) state of the Single Pilot. Gaze data would also be useful.
How would users **interact** with this IA?	Users might interact with this IA via a software interface embedded in the cockpit. Inputs to the system: • Vocal interaction: the pilot should be able to speak directly to the IA. • Embodied interaction: the pilot might also be able to interact with the IA via codified gestures. Outputs of the system: • Visual stimuli: the IA should produce information visualisations to ensure that all the information in the communication channel is put across in a clear and digestible way. • Auditory stimuli: the IA should be able to synthesise speech and produce

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	high-quality reproduction of communications.
What are the **main benefits** of this IA?	• Better, more streamlined decision-making. • Improved effectiveness.
What are the **main pain points** of this IA?	• Personalisation/adaptation to the domain. • Handling personnel data management, privacy, governance of data, and boundaries between airlines and pilots. • Providing continuous design assurance. • Trust: the pilot, especially at the beginning, might not trust the IA. • Joint human-machine evolution, with a suitable IA learning curve for humans and continuous adaptation.

Collaborative Cockpit Assistant IA Use Case Example
A single pilot is conducting a flight as usual, communicating with the IA to confirm all systems are in order. However, a bird strike on one of the engines triggers an emergency situation that forces the pilot to make an unexpected landing. The IA immediately helps with troubleshooting, eliminating the need for the pilot to consult the checklist to identify the correct procedure to follow. Then, it suggests a landing location based on the extent of the damage and the plane's current position. While the pilot focuses on the landing, the IA handles communication and provides status updates to the ATCOs involved in the operation, relieving the pilot of that responsibility.

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IA Concept 4: Personal Trainer AI

The Personal Trainer AI is an IA that would help improve pilots' performance in specific and unforeseen situations. On the one hand, the IA would learn how a pilot operates the aircraft and propose tailored training to improve efficiency on certain tasks. On the other hand, it would ensure that the pilot is also trained to face unexpected scenarios. The training will be delivered at all times, with the pilot continuously engaged even when other automated systems take care of routine tasks.

Personal Trainer IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Pilot(s). Either Single Pilots or Pilots in a traditional configuration.
What **user needs** would the IA address?	The pilots need • To be engaged with continuous, specific training to cope with different situations.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Constantly analysing pilots' performance, and identifying areas of improvement; • Providing personalised and targeted training to pilots. • Coaching pilots, giving them guidance in tasks in which they are less performant and providing feedback. • Providing review sessions for post-flight reflection and identification of improvement opportunities.
When would the IA be used?	The IA would be active all the time.

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What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer, Informer: this IA is expected to constantly observe pilots, providing information proactively or on demand, depending on the context. Coordinator: it will also proactively coordinate pilots' training activities, providing feedback, identifying priorities and leading through tailor-made training paths.
What **data** does the IA leverage?	External Data: the IA will leverage external data to understand the context the pilot is currently in (i.e.: weather data, etc.). Contextual Data: the IA will also use aircraft systems' data, flight context data, as well as information from incidents/unexpected events faced by other pilots that will be stored in a shared database. User's physiological measures: the IA needs to constantly monitor the physical (and possibly, mental) state of the Single Pilot. Gaze data would also be useful. Behavioural markers would also be relevant to get a full picture of pilot status.
How would users **interact** with this IA?	Users might interact with this IA via a software interface embedded in the cockpit. Inputs to the system: • Vocal interaction, textual interaction: the crew would be able to use voice and text to communicate directly with the IA. Outputs of the system: • Visual stimuli: the IA should produce interactive visualisations to ensure that all the information about certain training activities is clear and digestible. • Auditory stimuli: the IA should be able to synthesise speech and talk to the pilot, suggesting activities.

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What are the **main benefits** of this IA?	• Provide tailor-made training paths • Coach pilots, provide live feedback and structure improvement actions • Augment pilots' overall skills and capacity of coping with different scenarios. • Quickly disseminate best practices to deal with novel threats.
What are the **main pain points** of this IA?	• High cost of simulators and onboard resources if embedded training is considered. • High risk of situational awareness impairment if embedded training is considered. • Securing privacy on individual pilot weaknesses.

Personal Trainer IA Use Case Example
A pilot is making a landing approach at a challenging airport situated between mountains. The descent must be quick to reach the runway. As the pilot performed poorly in similar situations during training, the IA proactively recommends anticipated management of aircraft path, energy and configuration to allow for a stable approach. Nevertheless, the weather conditions are challenging and the pilot is unable to stabilise the aircraft safely for landing. The IA advises a go-around and supports the pilot in this phase. On the second approach, the pilot is able to touchdown the runway within the prescribed zone, but the deceleration is barely sufficient to stop the aircraft by the end of the runway. Soon after the operation, the IA provides the necessary feedback to the pilot, outlining training objectives, providing the details of the most appropriate simulator scenario, and scheduling additional hours of training focused on landing on this type of runway. This training aims to improve the pilot's skills and proficiency in challenging landing situations, thus ensuring safe and efficient landings in the future.

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IA Concept 5: AI Inspector

The AI Inspector IA would supervise the status of any piece of equipment in the cockpit, including other AI systems (autopilot, navigation, communication etc..) and would rapidly communicate to the pilots in case any problem is detected.

AI Inspector IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Pilots. • Maintenance team. Secondary users (indirectly impacted by the IA): • OEM (Original Equipment Manufacturer).
What **user needs** would the IA address?	The primary users need • Assurance that all the equipment and AI systems on the aircraft function as intended.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring and managing multiple systems running concurrently in the cockpit, such as autopilot, navigation and communication systems. • Detecting any systems malfunctions or errors and notifying the crew in real time. • Analysing data from various systems to identify patterns (or anomalies). • Providing suggestions and recommendations to optimise the use of systems for safer and more efficient flights • Ensuring that all AI systems on board are compliant with regulations.

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When would the IA be used?	This IA would be monitoring all other AI systems all the time.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer, Informer: this IA is expected to be used on-demand by pilots whenever they want to know about the state of onboard equipment. However, in case of anomalies or malfunctioning, the IA might proactively alert pilots.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from sensors and other AI systems.
How would users **interact** with this IA?	Users might interact with this IA via a software interface embedded in the cockpit and connected to all other AI systems. Inputs to the system: • Vocal interaction: the pilot should be able to directly ask questions in natural language to the IA, requesting an update on the state of the system(s). Outputs of the system: • Visual stimuli: the IA should produce information visualisations to ensure that all the information about the state of AI systems is digestible. • Auditory stimuli: the IA should be able to synthesise speech and produce answers in natural language.
What are the **main benefits** of this IA?	• Enhanced Safety. • Increased efficiency. • Improved situational awareness. • Better compliance (the IA can ensure that all AI systems on board are compliant with industry regulations and standards, thus it

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	would reduce the risk of regulatory violations).
What are the **main pain points** of this IA?	• Necessity of creating a legal/business framework for supporting data exchange between airlines and manufacturers. • Technical difficulties, specifically related to inter-systems communications. • Dangers of false alarms: if the IA is not calibrated properly, it may generate false alarms which may be distracting for pilots.

AI Inspector IA Use Case Example
During a flight, the AI inspector detects an unusual amount of traffic to the aircraft's onboard network. The IA immediately alerts the pilots and ground staff of a potential cyberattack. The pilots quickly implement a pre-defined emergency response plan, which consists of switching to a secure frequency to communicate with ATCOs, while the IA works to identify the source and nature of the attack. The IA identifies that the attack is targeting the aircraft's avionics AI systems, which control the flight controls and navigation equipment. The IA advises the pilots to take manual control of the flight controls, and the ground staff work to isolate the affected systems from the onboard network to prevent the attack from spreading.

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2.4. Airport concepts

The IAs in the Airport segment aim to improve the user experience on the user side of the airport. The targeted users for these IAs are:

- Passengers: Individuals who use the airport for travel purposes.
- Security Officers: Part of the airport staff responsible for passenger screening, threat detection, and risk analysis.
- Airport Crew: Part of the airport staff responsible for baggage handling, maintenance, and customer service.

In addition, all service providers involved in the airport would benefit from the use of these AI systems, as they can improve the efficiency and effectiveness of all airport operations.

IA Concept 1: Multimodal Travel Planner

This IA will help passengers in scheduling multimodal journeys. It will leverage a large database made of different data types (weather, traffic, transportation availability, cost) and will propose the most efficient solutions to users based on their preferences (i.e.: economic costs, green-travel considerations, solo or group travels).

Multimodal Travel Planner IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Passengers. Secondary users (indirectly impacted by the IA): • All service providers involved (ATM, Railways, UAM etc..).
What **user needs** would the IA address?	The primary users need • To easily book a journey (instead of wasting lots of time checking too many options) from and to home, passing by airports or other transport hubs. • To minimise their carbon footprint. • To optimise time constraints.

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	• To easily identify more comfortable options. • To communicate directly with all service providers. • To adapt to disruptions.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Finding the best solution for journeys from A to B by cross-referencing all the data. • Providing passenger assistance in selecting multimodal journeys according to their preferences and needs. • Choosing amongst an ever-increasing complex array of route/travel options. • Making decisions to plan and integrate different transport modes. • Integrating real-time information during the journey. • Factoring in weather data in the decision-making (predicting risks and extreme events). • Proposing integration with social media apps (to suggest other travellers with the same goal). • Performing real-time monitoring. • Mitigating disruption based on user preferences and priorities. • Including travel risks in decision-making. • Rebooking tickets and suggesting re-routing as needed.

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When would the IA be used?	The passenger can use the IA any time they want to plan and organise a trip. It might especially be useful in times of disruptions.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Secretary, Executor: this IA is expected to be used on-demand by passengers to suggest options. When the users agree with one of the suggestions, the IA might automatically proceed to buy tickets and set up bookings.
What **data** does the IA leverage?	External Data: the IA will leverage external data coming from all service providers about network and traffic state. Structured data: passenger travel data and preferences.
How would users **interact** with this IA?	Users might interact with this IA via several devices. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Vocal, textual interaction: the user can communicate their wishes to the IA in vocal or textual forms. Outputs of the system: • Visual stimuli: the IA should produce information visualisations to ensure that all the information options for travel are digestible. • Auditory stimuli: the IA should be able to synthesise speech and produce answers in natural language.
What are the **main benefits** of this IA?	• Travel planning support with an alleviated workload for users.

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	• Improved user experience and less stress in travel planning • Benefit for service providers as the AI assistant provides mitigations, leading to fewer dissatisfied customers.
What are the **main pain points** of this IA?	• Explainability of the IA's decision-making process. • Cost transparency in travel planning and ticket purchases. • Ensuring clarity of user intentions, priorities, and preferences. • Integration of multi-ticketing options. • Finding the appropriate threshold for inadequate solutions to prevent unsatisfactory results. • Addressing conflicting priorities to achieve optimal travel planning. • Prone to marketing manipulations that may lead to biassed suggestions or options.

Multimodal Travel Planner IA Use Case Example
A passenger wants to travel from Rome to Bergen but is concerned about minimising their carbon footprint. The IA presents a few options that meet the passenger's criteria, such as a flight from Rome to Copenhagen, a train ride from Copenhagen to Oslo, and finally an electric bus from Oslo to Bergen. The IA suggests a single ticket that would cover all of the different legs of the journey, along with any necessary information or instructions about each stage of the trip. Meanwhile, the service providers exchange information about passengers who use the multimodal travel planner. They work together to coordinate the flow of passengers, prevent overcrowding, and develop strategies for dealing with any disruptions.

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IA Concept 2: Airport Guard

This IA will be used by safety and security institutions. It will monitor the behaviour of passengers in the airport and will leverage biometric data to identify situations that might lead to security threats.

Airport Guard IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Security officers Secondary users (indirectly impacted by the IA): • Passengers flowing in the airport
What **user needs** would the IA address?	The primary users need • Assistance in identifying and preventing acts of terrorism in airports.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Monitoring of people's behaviours within the airport. • Identify and communicate possible risks of terrorist attacks
When would the IA be used?	This IA would be active all the time in the airport.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Informer: this IA will inform authorities directly when it detects something suspicious.
What **data** does the IA leverage?	Visual Data: the IA will leverage cameras inside the airport. User's physiological measurements: this IA should also be capable of monitoring certain physiological parameters of passengers.

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How would users **interact** with this IA?	Users might interact with this IA via an interface in the security centre of the airport. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Vocal, textual interaction: the user should be able to search and filter past accidents from the database either via voice or text. Outputs of the system: • Visual stimuli: the IA should produce visualisations to signal certain passengers to the security officers. • Auditory stimuli: the IA should be able to generate sounds to draw the attention of the security officer if a critical situation has been identified.
What are the **main benefits** of this IA?	• Security officers would be freed up of routine checks to passengers and would have more time. • Safety in airports would be increased.
What are the **main pain points** of this IA?	• Privacy. • Bias. • Possible misinterpretation of certain data. • Accountability, considering the shift of responsibility of detecting threats from the security personnel to the system.

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Airport Guard IA Use Case Example

A distressed passenger arrives at the entrance of the airport, exhibiting erratic behaviour with a knife hidden in his pocket. The IA, equipped with facial recognition technology, recognises the angered expression and alerts the security personnel in real-time upon the arrival of the passenger. The security personnel quickly respond to the situation, confiscate the knife, and take appropriate measures to ensure the safety of the other passengers. The IA continues to monitor the situation and provides ongoing support to the security personnel as needed.

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IA Concept 3: RIDE: Rapid Integrated Digital Entry

This IA will render the typical airport experience (security checks, boarding etc..) completely obsolete. It would automate the entire process by using biometric data (pupil, fingerprint, face) as a boarding pass.

Rapid Integrated Digital Entry IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Passengers Secondary users (indirectly impacted by the IA): • Airport staff and crew.
What **user needs** would the IA address?	The primary users need • To move around the airport and board the flight as smoothly as possible, without wasting too much time.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Providing a seamless journey through the airport by boarding the aircraft via smart scanners (and eliminating physical or electronic passes in the process). • Giving each passenger a personalised journey to the gate, with the possibility of easily accessing (or skipping) duty-free stores. • Eliminating security screening for most passengers, with only random screening (sample screening) in special cases.
When would the IA be used?	When a passenger enters the airport.

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What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Executor: this IA will automatically take actions without the user ever needing to intervene.
What **data** does the IA leverage?	Visual Data: the IA will leverage cameras inside the airport. User's physiological measurements: this IA should also be capable of monitoring certain physiological parameters of passengers. Structured Data: Passengers' travel data and preferences.
How would users **interact** with this IA?	Users might interact with this IA via a mobile application. Inputs to the system: • Desktop or mobile User Interface: the IA will have a desktop or mobile UI that users can interact with (via mouse and keyboard, or touchscreen). • Textual information: the user can input personal data via text fields. Outputs of the system: • Visual stimuli: the IA should have an easy-to-use graphical user interface that users can interact with • Auditory stimuli: the IA should be able to generate sounds to draw the attention of the security officer if a critical situation has been identified.
What are the **main benefits** of this IA?	• Savings in time and in airport resources due to reduced queuing and faster boarding processes. • Personalised experience tailored to each passenger's preferences and needs.

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	• Reduced stress and anxiety in the boarding process. • Enhanced security through the use of advanced biometric technology.
What are the **main pain points** of this IA?	• Difficulty in ensuring adequate security measures and identifying potential threats. • Privacy and ethical concerns, as passengers may feel uncomfortable being tracked and monitored. • Risks of AI bias and unintended consequences affecting the accuracy and fairness of security measures. • Cybersecurity issues, such as the possibility of biometric breaches or other cyberattacks. • Real physical twin issues, where the digital assistant may incorrectly identify a passenger as being in two places at the same time. • Lack of transparency in how security measures are implemented and how passenger data is used. • Behavioural changes due to the impact of video surveillance, which may lead to reduced privacy and freedom of movement for passengers.

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Rapid Integrated Digital Entry IA Use Case Example
A passenger arrives at the airport and their biometric data, stored in an app, is passed by the IA to the airport security centre. The airport recognises the passenger via cameras, verifies the security clearance, and allows them to quickly board the plane without any further security checks or having them stop at check-in counters. The passenger enters the airport and proceeds to the gate to board the plane. On the way there, the app may suggest shops and services that might be interesting to the user.

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IA Concept 4: Airport White Rabbit

This IA would improve airport navigation by efficiently guiding passengers to their desired destinations, all while providing an enjoyable interactive experience. In the airport, passengers would be able to explore various amenities and services highlighted by the IA, leading to a more convenient and streamlined travel experience. Ultimately, this would result in better flow management for the airport, reducing congestion and ensuring a smooth and engaging journey for all passengers.

Airport White Rabbit IA Summary	
Who are the end users?	Primary users (directly impacted by the IA): • Passengers Secondary users (indirectly impacted by the IA): • Airport staff.
What **user needs** would the IA address?	The primary users need • To navigate the airport efficiently and easily.
What **tasks** would this IA accomplish?	The IA would be responsible for accomplishing the following tasks: • Identifying individual passengers and learning from their past airport passages. • Assisting with check-in procedures. • Facilitating the boarding process. • Providing orientation and wayfinding assistance within the airport. • Managing time and security control to ensure a safe and efficient journey. • Facilitating luggage delivery and pickup.

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	• Personalising services to meet each passenger's unique needs, including access to duty-free stores and other amenities.
When would the IA be used?	When a passenger enters the airport.
What is the envisaged role of this IA in terms of **Human-AI Teaming**?	Observer, Informer, Coordinator: this IA will inform the user on-demand or proactively by suggesting possible routes to take in the airport. Globally, it will coordinate the passenger's experience of the airport.
What **data** does the IA leverage?	Visual Data: the IA will leverage data from the smartphone's camera.
How would users **interact** with this IA?	Users might interact with this IA via a mobile application. Inputs to the system: • Textual information: the user can input personal data, such as preferences and objectives, via text fields. Outputs of the system: • Visual stimuli: the IA might leverage AR (Augmented Reality) to overlay visual indicators through the mobile phone's camera. • Auditory stimuli: the IA should be able to generate sounds to draw the attention of the user to a specific point of the airport.
What are the **main benefits** of this IA?	• Efficient flows of passengers in the airport. • Better user experience (UX)
What are the **main pain points** of this IA?	• Privacy. • Fairness.

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Airport White Rabbit IA Use Case Example
A passenger arrives at the airport and is in a hurry to reach the gate. As she has never been to that airport before, she is unsure of the directions to take. The IA can assist the passenger in navigating the airport and reaching the gate as quickly as possible by displaying Augmented Reality directions through their phone's camera. Along the way, the IA could also suggest activities that the passenger could do within the airport, if there is sufficient time before boarding.

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Conclusions

The aviation industry is envisaged to face a complex and challenging future. Projections for aviation landscapes in 2030 and 2050 (HAIKU, 2023) indicate that much higher levels of complexity for all operators can be expected. The projected increase in the number of operations, the introduction of UAM, and the need to adapt to more frequent extreme weather events and accommodate new ways of living will bring about radical transformations in aviation.

The IA concepts developed in HAIKU's Task 3.4 are envisioned as possible solutions to these challenges. They are not full-fledged systems ready to be implemented, but rather a human-centred reflection of what the industry may need going forward. They capture an initial understanding of relevant benefits and explore research directions. The proposed IA concepts aim to enhance safety, improve operational efficiency, reduce costs and integrate the environment into decisions at every level. However, there are several aspects that need to be addressed, such as issues related to privacy, over-reliance, and trust. HAIKU's approach is to inform every design phase with a strong human-centred perspective, to ensure that the technology will not backfire and will be beneficial to the industry in the long run.

Oversimplifying the picture, the main driving values that emerged in HAIKU are:

- In ATM, IAs can keep ATCOs' workload under control and support network managers in facing the envisaged airspace complexity. AI can integrate different sources of data and support decision-making, improving efficiency and safety while minimising costs.
- In UAM, IAs can ensure safety in a scenario of massive traffic growth projected. AI can help integrate a large network of unmanned aerial systems (UASs), which will need to operate together in a synchronised way.
- In the cockpit, AI can improve human performance and maximise safety. AI can ease the transition towards SPOs and provide better, personalised training. AI applications have the potential to significantly change the pilot experience during both short and long-haul flights.
- In the airport, AI can improve the user experience by enabling smoother travel from booking to boarding. AI can also help promote greener and safer travel and more efficiently prevent possible disruptions.

The concepts proposed in this document will be presented to the public during HAIKU's 1st dissemination workshop (Brussels, June 26th-27th 2023). During the event, feedback from the aviation community will be collected with the aim of identifying which IA concepts can be applicable and beneficial in the aviation industry, thus enabling to determine the most promising avenues for AI application in such a complex industry.

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Annex A: Workshop materials

Figure 1: example of a card used in the physical workshops.

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Figure 2: example of a card used in the digital workshop.

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Figure 3: example of a card used in the digitall workshop, with labels applied.

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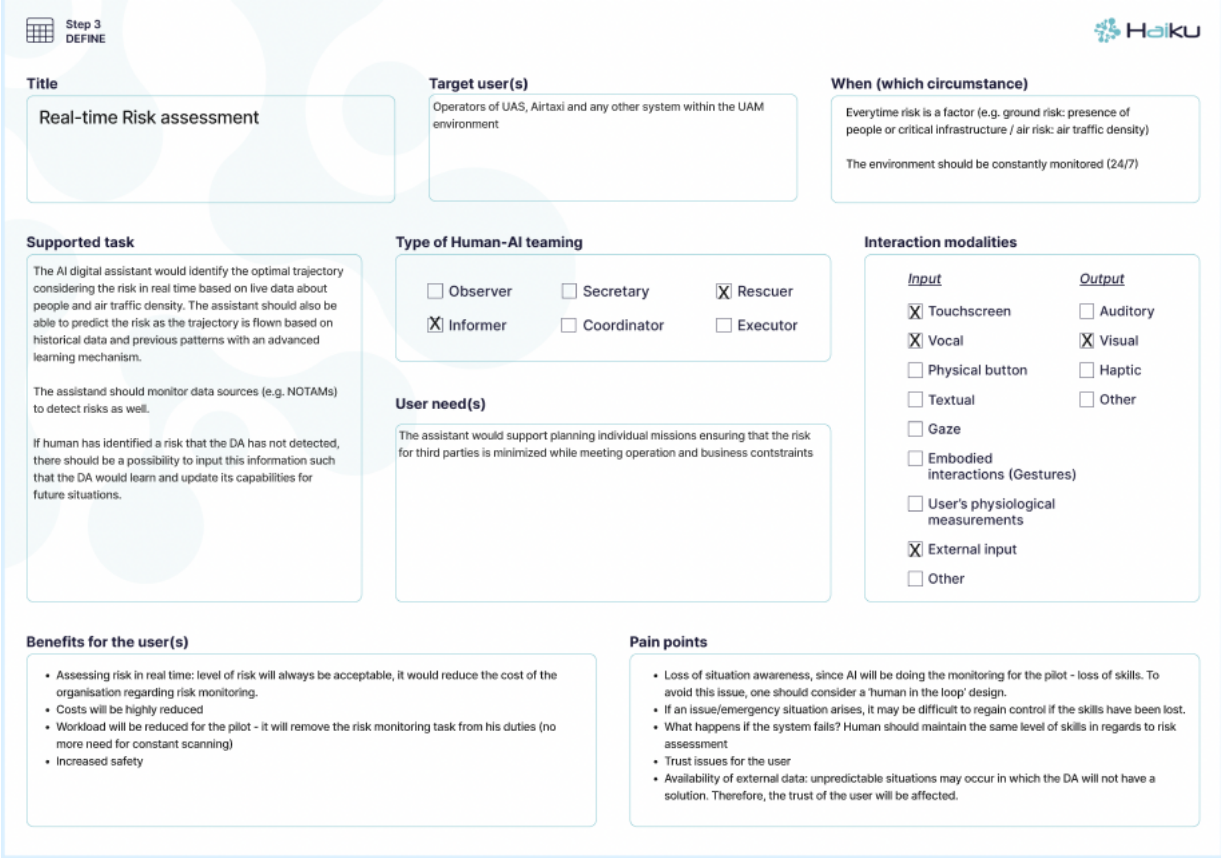

Figure 4: an example of a filled-out grid for the Real-time Risk assessment tool.

Annex B: Discarded IA concepts

This Annex section presents four noteworthy ideas, one per segment, that didn't make it to the final selection. Although these concepts may not be fully developed and detailed, they could still be valuable to consider when exploring AI opportunities in aviation. The concepts are presented in the forms of the grid filled out by participants:

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UAM: Delivery plan optimiser

Category: UAM

Haiku

Title

Delivery plan optimiser

Target user(s)

UAM Operator (ex.: Delivery service)

When (which circumstance)

Supported task

- Proposes flight plans for the day according to orders of priority (emergency, goods deliveries, different services, etc.)
- Optimize time and avoid delays between deliveries

User need(s)

Optimise all paths to find the most optimal one. Go from delivery points to depots with the least amount of time lost.

Type of Human-AI teaming

☐ Observer	☐ Secretary	☐ Rescuer
☐ Informer	☒ Coordinator	☐ Executor

Interaction modalities

Input	Output
☐ Touchscreen	☐ Auditory
☐ Vocal	☐ Visual
☐ Physical button	☐ Haptic
☐ Textual	☐ Other
☐ Gaze	
☐ Embodied interactions (Gestures)	
☐ User's physiological measurements	
☐ External input	
☐ Other	

Benefits for the user(s)

Massively increases efficiency of delivery operations

Pain points

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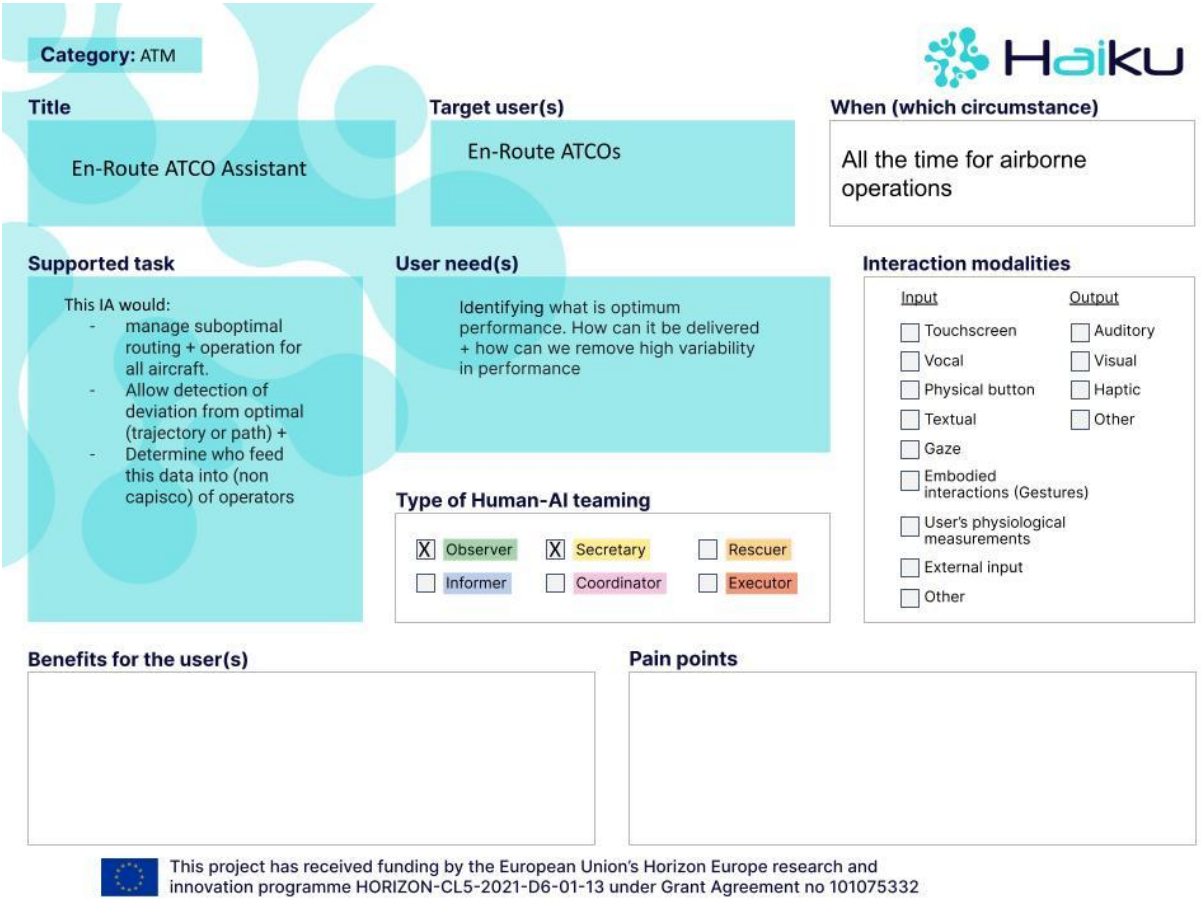
ATM: En-route ATCO assistant



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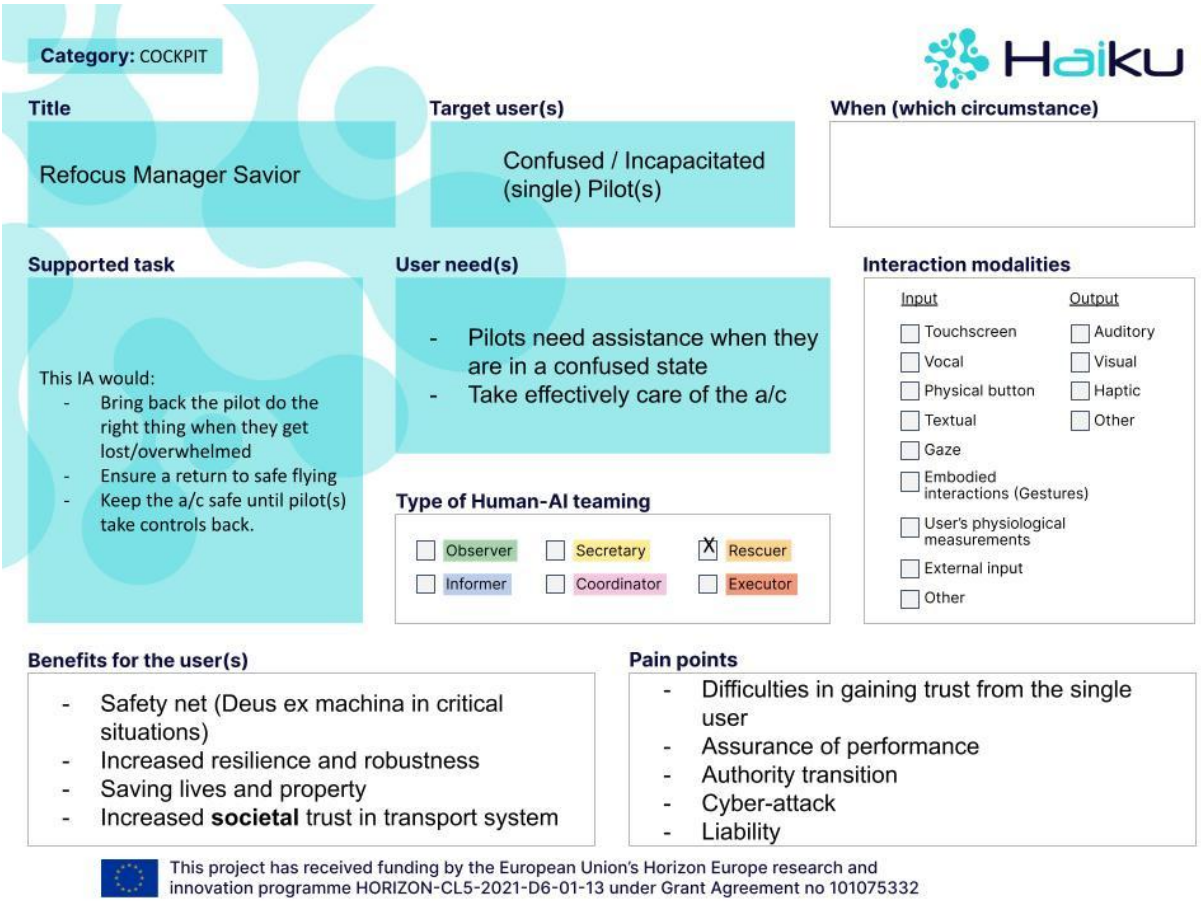
Cockpit: Refocus manager savior



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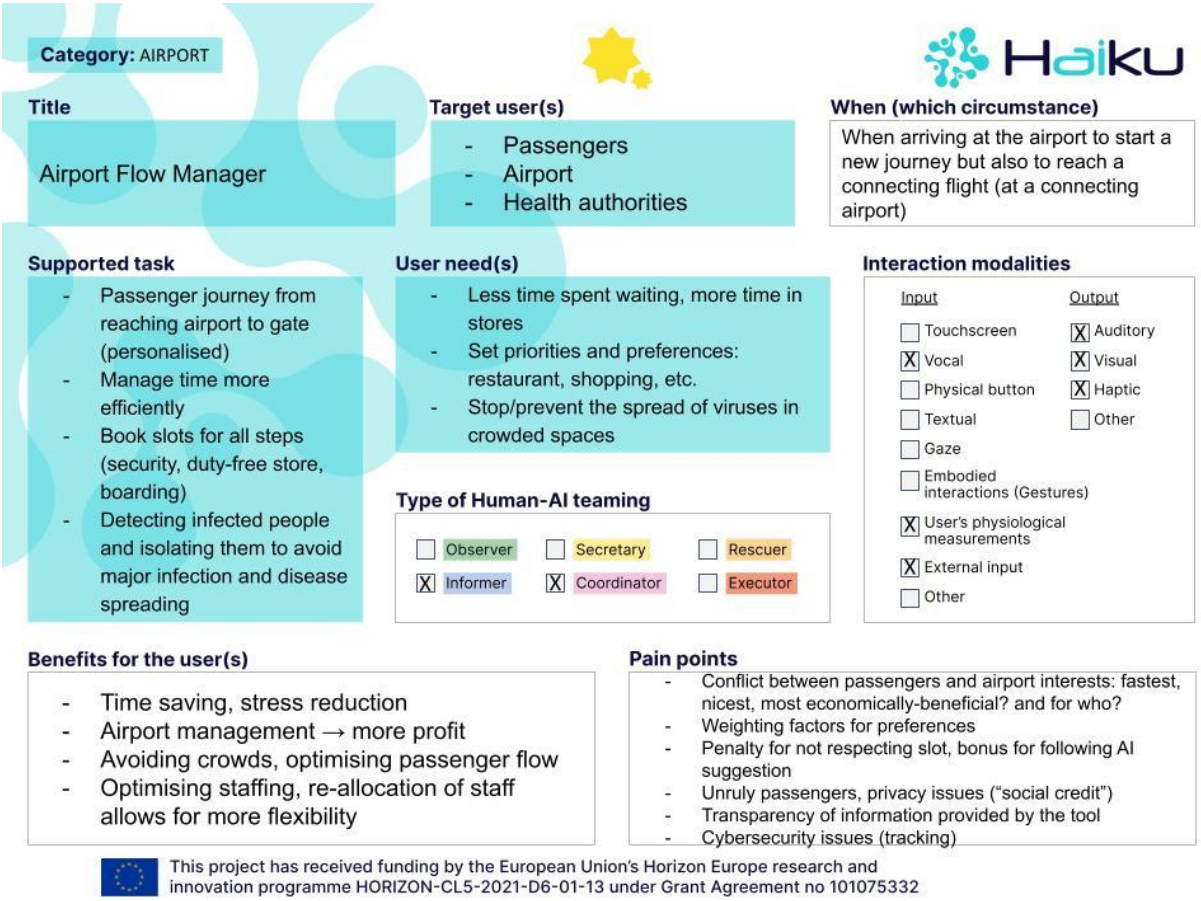
Airport: Airport Flow Manager



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