Harvis {^_^}

Human Aircraft Roadmap for Virtual Intelligent System

This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 831884. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Clean Sky 2 JU members other than the Union

Presentation of HARVIS Project

Presenter: HARVIS Partners

Date: 5^{Th} February 2020

Place: **Brussels**

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Outline

1. Project Overview
    - Objectives of HARVIS
    - Partners
    - Advisory Board
2. Achievements in 2019
    - Deliverables, Milestones and Meetings
3. Use Cases
    - Concept
    - Progress
4. Validation Process
    - Approach
    - External Feedback
5. Next Steps

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1. Project Overview

- The overall objective of HARVIS

Identify how cognitive computing algorithms implemented in a digital assistant could support the decision making of a single pilot in complex situation.

Human Aircraft Roadmap for Virtual Intelligent System

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Human Aircraft Roadmap for Virtual Intelligent System

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1. Project Overview

- Main objetives:

1. Detailed **State of Art** about **cognitive computing algorithms**.
2. Analyze the scenarios where a “digital assistant” will produce the **greatest benefits to the pilot.**
3. To **identify the technologies and the shortcomings** that prevent these technologies to be applied successfully in real life
4. Study **the benefits of a potential decision making** with enhanced information which might not be available on – board.
5. Benefits of the **insertion of these technologies into the realistic working practices**.
6. To **identify collateral risks**.

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1. Project Overview

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- Partners:

Deepblue

CVBLAB

ENAC

skylife

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1. Project Overview

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- Advisory Board:

Roles

- Industry
- Users
- Liability experts
- Automation experts
- Regulators

Expected support

- STATE OF THE ART + ROADMAP
- USE CASES: Are the use cases relevant and realistic for the involved stakeholders?
  - They are aligned with expectations on future aviation scenarios
  - They are feasible in the 2035+ timeframe
  - They add value for the different stakeholders
- HUMAN-MACHINE PARTNERSHIP FRAMEWORK & ENVELOPE
- RESULTS: Participate to the final demonstration and provide feedback

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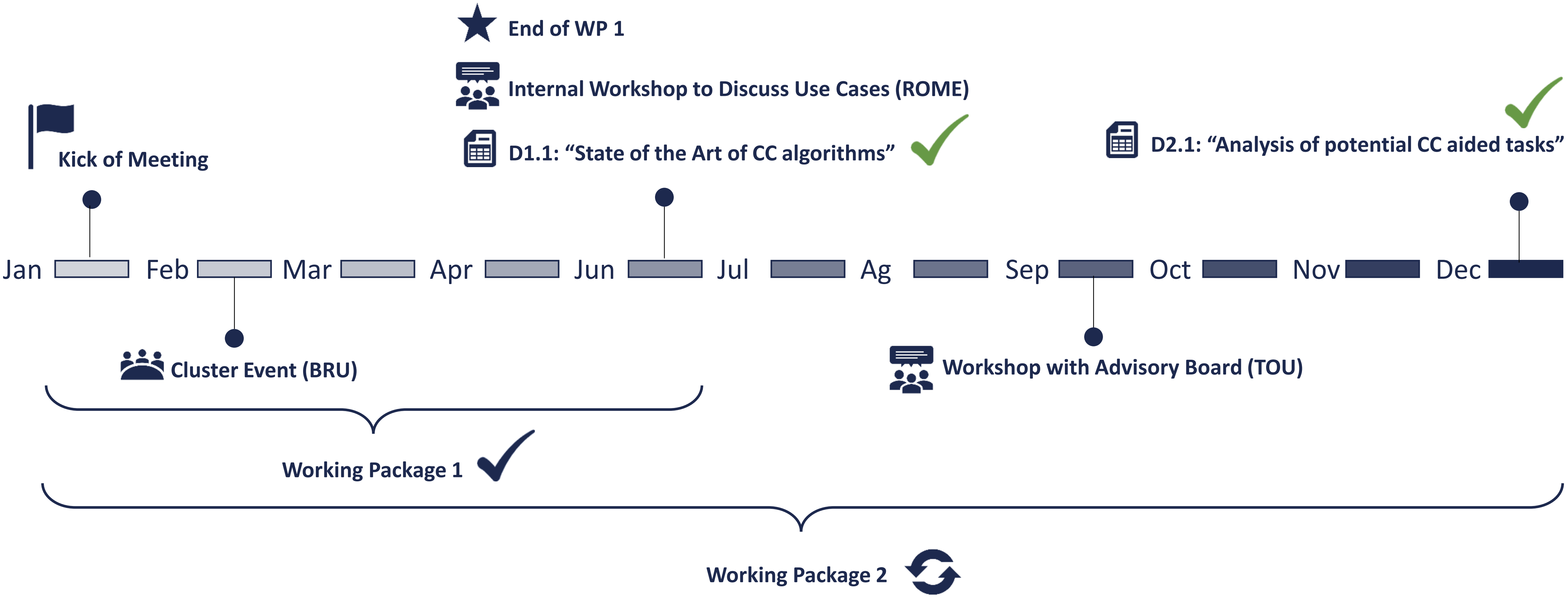
2. Achievements in 2019



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2. Achievements in 2019

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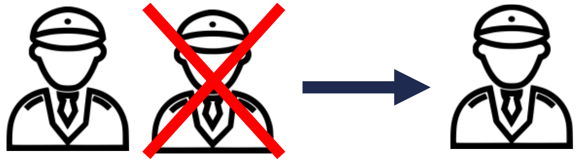
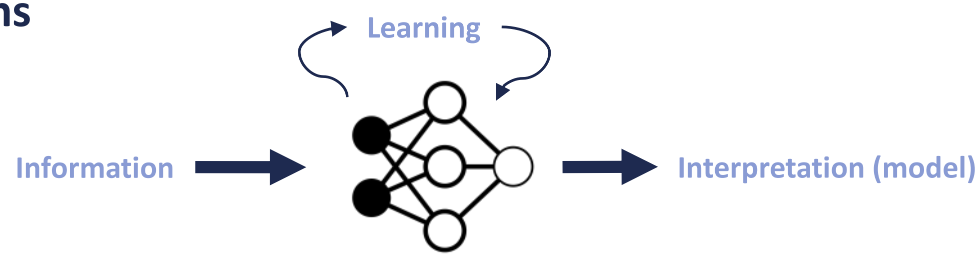
- Contents

Single-Pilot Operations (SPO)

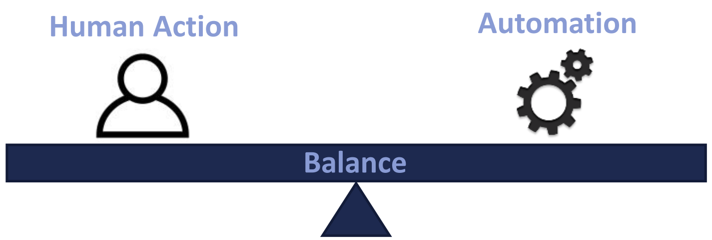
Reducing commercial cockpit to a single pilot



Machine Learning (ML) and Cognitive Computing(CC) Algorithms

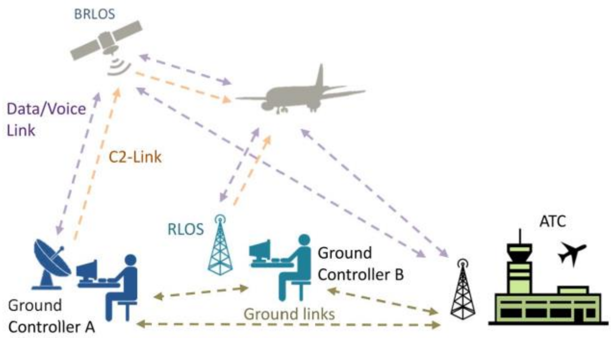


Human Factors



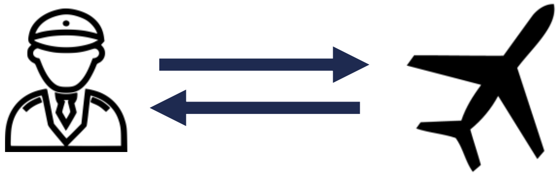
Virtual Pilot Assistant Architecture

Multiple links used to support transfer of data and information between aircraft and various agents.



Adaptative/Cognitive HMI

Promote interaction between human and machine to achieve a "common goal"



Clean Sky

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2. Achievements in 2019

- AI applications in different sectors

Financial
- Speed up financial work (i.e.: Automatic digit recognition)
- Create personal saving plans
- Fraud/laundering detection

Retail
- Stock control
- Market /customer preferences research
- Customers' demand prediction

Education
- Intelligent Tutor Systems
- Automatic Test Evaluation Systems
- Virtual Reality – Behaviour analysis

Automotive
- Road safety and protection
- Autonomous cars

Healthcare
- Image analysis (CNNs)
- Psychiatric Diseases Detection (NLP)
- Detect pandemics

Aerospace
- Controllers decission support systems
- Trajectory prediction
- Conflict detection
- Fuel consumption reduction

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2. Achievements in 2019

- ML and CC algorithms to solve AI tasks

Image Classification: Automatically assigning a label class to a given input image.

Object Detection: locating image elements and determining which class it is part of.

Content Generation: Understand essence of data and generate new samples.

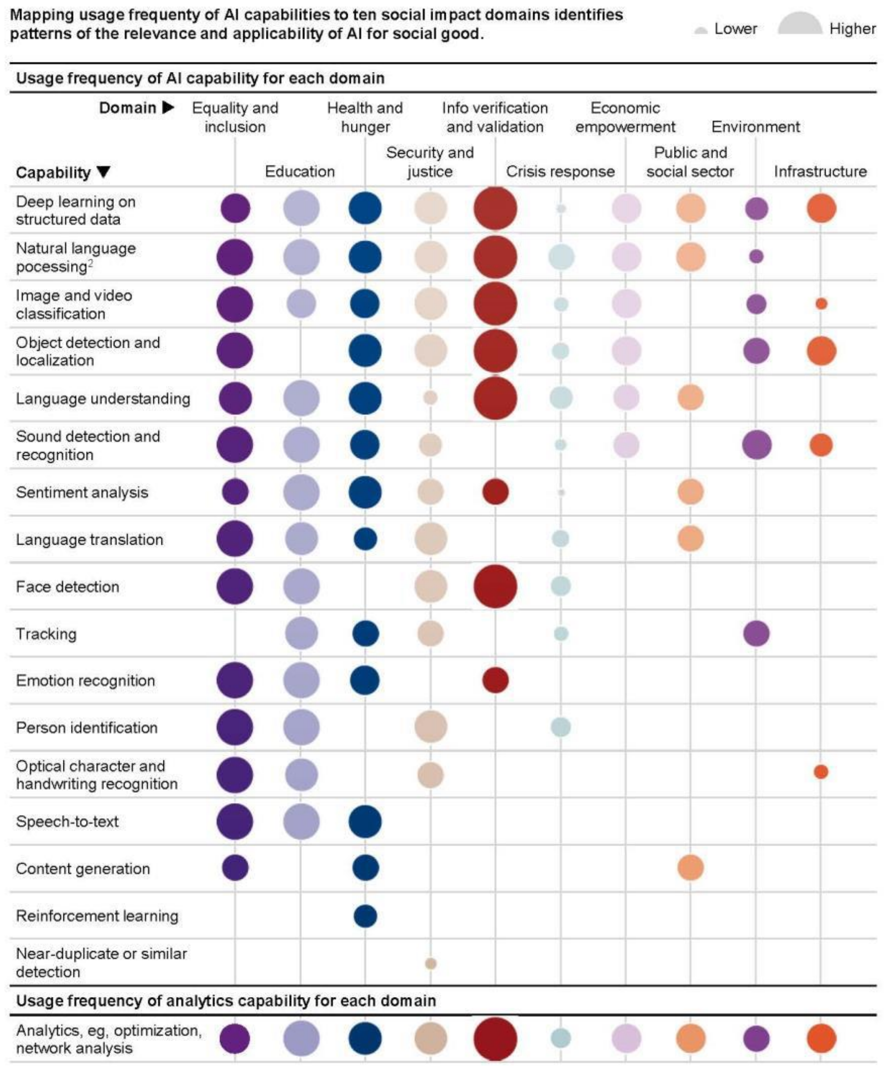
Image and Video Captioning : Extracting information from pixels and generate descriptive phrases.

Emotion Recognition: Extraction of face features and classification of expressions.

Reinforcement Learning: Trial and Error procedures used to learn certain behavior by a machine.

Natural Language Processing: Automatic correction, suggestions to answer emails, machine translation and voice recognition

Sentiment Analysis: Extracting subjective information from text or spoken language and identifying feelings, emotions and opinions.



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2. Achievements in 2019

Purpose of the deliverable 2.1:

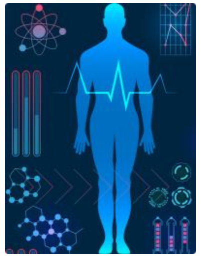
Highlight the situations where a digital assistant would be relevant by analysing the work of pilots in the cockpit and studying the already existing virtual assistant concept.

Task analysis inside cockpit

- The role of automation
- Crew resource Management
- Cockpit and pilot's work environment

- Exterior assistances

Virtual assistant concept



Crew status analysis

Situation diagnostics

Multimodal conversation (natural interaction)

Short time horizon decision

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Use cases elaboration process

8 PROPOSED FROM THE CONSORTIUM	4 SELECTED, AFTER OFF-LINE FEEDBACK FROM PILOTS	1 SELECTED, 1 NEW AFTER AB WORKSHOP	ENRICHED&REFINED AFTER FEEDBACK FROM OPERATIONALS
INTERNAL EXPERTS	AB PILOTS, HF EXPERS, SAFETY EXPERTS	ADVISORY BOARD	AIRLINE PILOTS

AB Meetings held end of September with AIRBUS, TRANSAVIA and AIRFRANCE

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2. Achievements in 2019

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Considered uses cases

Meteorological issue

Interpret meteorological information and support pilot for related decision making

Detect fatigue

Pilot’s fatigue assessment, alerting if necessary

Procedure compliance in case of System/Engine failure

Support pilot for the procedure application

Detect workload

Pilot’s workload assessment, identification of the causes, suggestion of countermeasures

Abnormal aircraft behaviour: icing on wings

Improvement of pilot situation awareness

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2. Achievements in 2019

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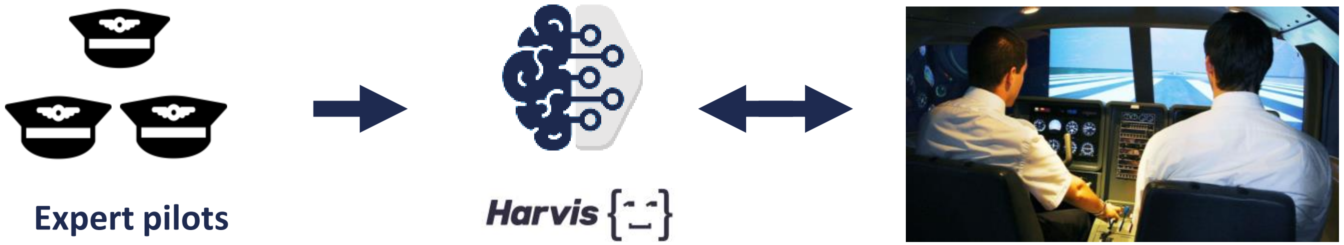
Selected use cases

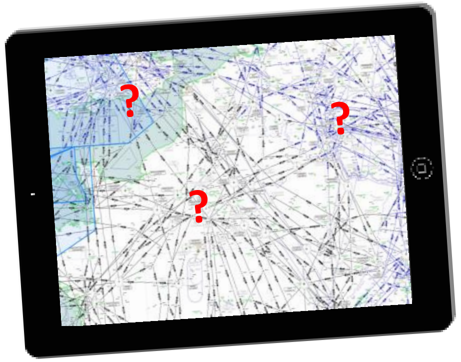
Non-Stabilized approach support

Bringing the expertise of many pilots in the cockpit to support the go-around decision making



Aircraft Dynamic Rerouting

Decision making support during diversion



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UC 1: Non Stabilized approach support

Conceptual problem:

In single pilot operation, the pilot flying won’t have the support and the monitoring of the second pilot to make the appropriate decisions.

97% of non-stabilized approach are not followed by a go-around decision that is required by SOP. As a consequence, an AI based on SOP only would go against pilot decision during most of non-stabilized approach.

An AI based on the expertise of many pilots will **assist** the pilot during the approach by **alerting** about parameters deviations and **supporting** the go-around decision.

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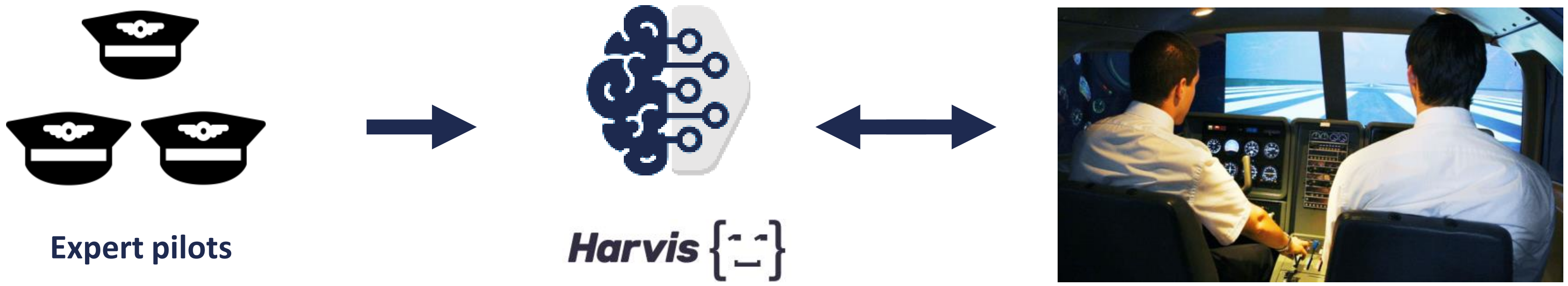
3. Use Cases

Based on the expertise of many pilots:

1. To support pilot’s decision making during the approach
2. To support pilots for approach stabilization



The assistant could:

- Provide support for go around decision making
- Alert the pilot in case of parameter deviations
- Suggest corrective actions

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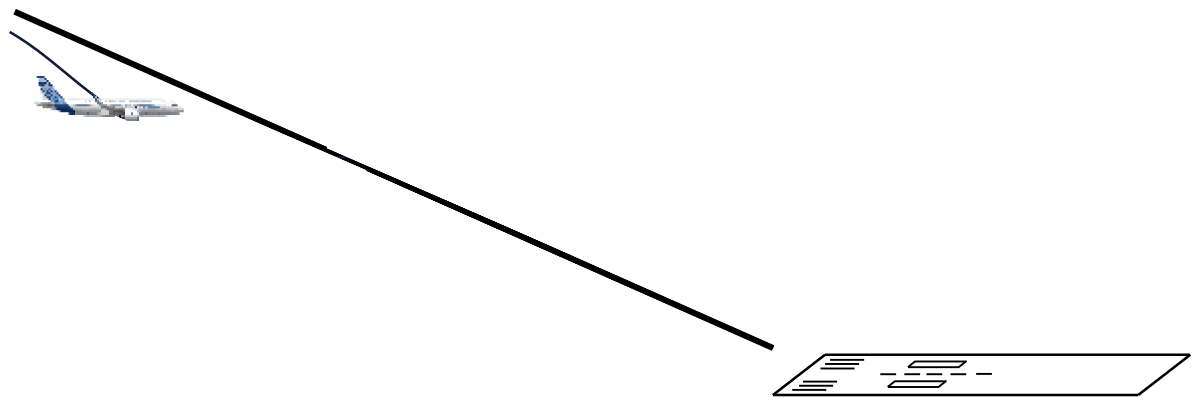
UC1: Situation 1

Context : The AC has an unusual trajectory approaching stabilization point



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UC1: Situation 1

Context : The AC has an unusual trajectory approaching stabilization point

Specific pilot's behaviour: The pilot does not manage to stabilize the Aircraft for landing

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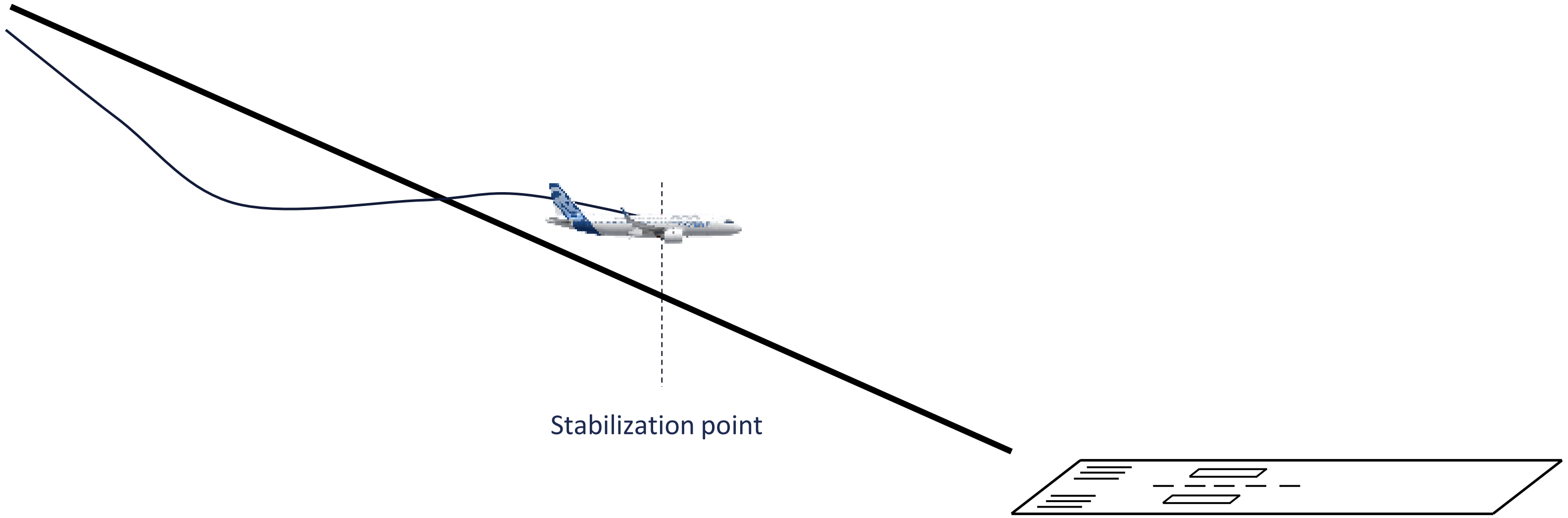
3. Use Cases

UC1: Situation 1

Context : The AC has an unusual trajectory approaching stabilization point

Specific pilot's behaviour: The pilot does not manage to stabilize the Aircraft for landing

Expert system: The IA detects based on many pilots expertise that the situation normally lead to a go-around.



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3. Use Cases

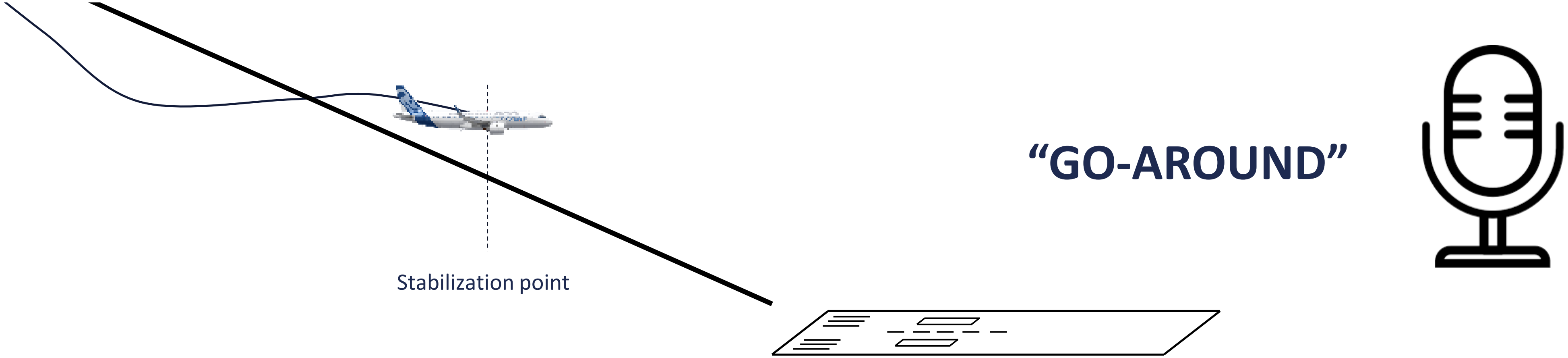
UC1: Situation 1

Context : The AC has an unusual trajectory approaching stabilization point

Specific pilot's behaviour: The pilot does not manage to stabilize the Aircraft for landing

Expert system: The IA detects based on many pilots expertise that the situation normally lead to a go-around.

Digital assistant: During the final step of the approach, a voice advises the pilot to go-around.



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3. Use Cases

UC1: Situation 2

Context : The automatic system fails or is disconnected by the pilot. The pilot has to manually control the plane.

AUTOMATIC SYSTEM

MANUAL SYSTEM

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UC1: Situation 2

Context : The automatic system fails or is disconnected by the pilot. The pilot has to manually control the plane.

Specific pilot's behaviour: Pilot is undecided or overwhelmed by the situation and doesn't check some important flight parameter in the control panel (f.e. altitude).

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UC1: Situation 2

Context : The automatic system fails or is disconnected by the pilot. The pilot has to manually control the plane.

Specific pilot's behaviour: Pilot is undecided or overwhelmed by the situation and doesn't check some important flight parameter in the control panel (f.e. altitude).

Expert system: The developed eye-tracking algorithm detects that the pilot is not paying enough attention to the area corresponding to the altitude.

ROI of the **altitude** variable

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3. Use Cases

UC1: Situation 2

Context: The automatic system fails or is disconnected by the pilot. The pilot has to manually control the plane.

Specific pilot's behaviour: Pilot is undecided or overwhelmed by the situation and doesn't check some important flight parameter in the control panel (e.g. altitude).

Expert system: The developed eye-tracking algorithm detects that the pilot is not paying enough attention to the area corresponding to the altitude.

Digital assistant: After pilot misbehavior identification, a voice system issues a specific indication.

"CHECK ALTITUDE"

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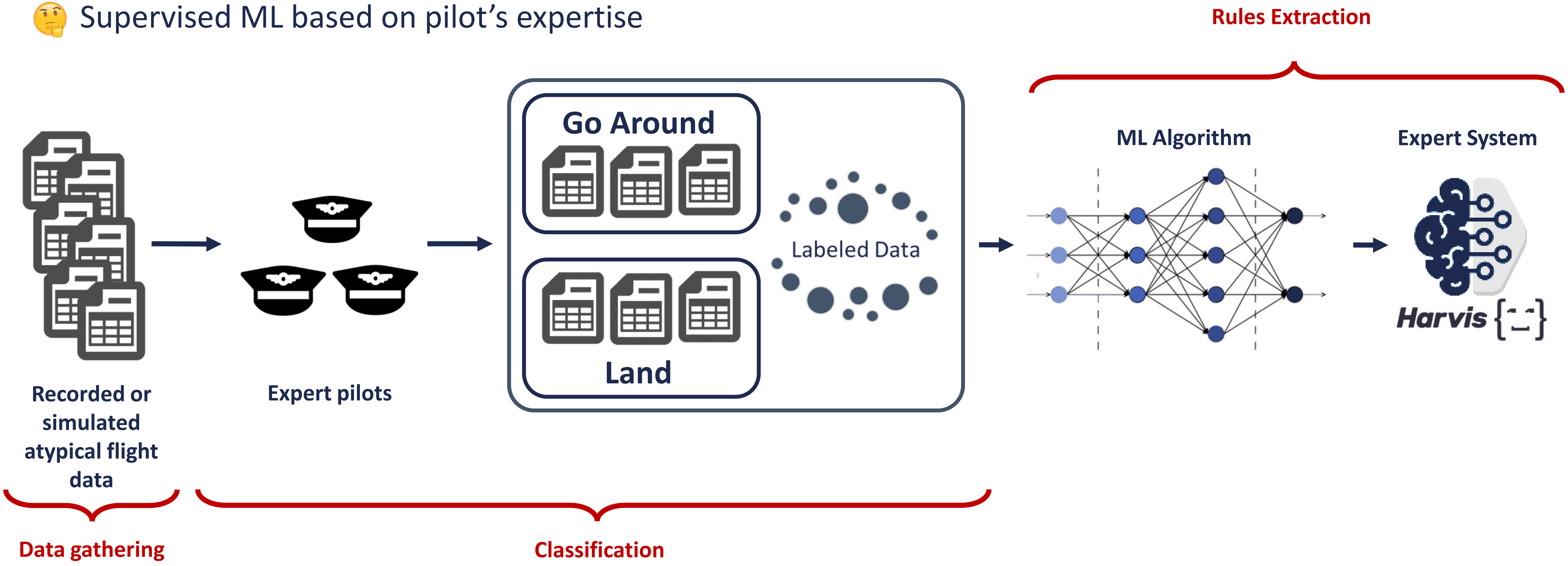
3. Use Cases

UC1: AI training (how the AI is developed)

🤔 Supervised ML based on pilot's expertise



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3. Use Cases

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UC1: Test with IA (how the IA is validated)

Matlab

Generate different scenarios

Test on ENAC's Simulators

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Validation

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3. Use Cases

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TYPE OF AI

ML,CC

EXPERT SYSTEMS
(RULES COMING FROM IA)

INPUT USED BY AI

PILOT (E.G. REAL TIME MONITORING)

A/C (E.G. SENSORS)

EXTERNAL (E.G. RADIO, GROUND)

Virtual pilot assistant

IA HMI

VISUAL

AUDIO (E.G. VOICE)

HAPTIC (E.G. VIBRATIONS GRAMMAR)

INFO ACQUISITION
INFO ANALYSIS
DECISION MAKING
EXECUTION

TYPE OF SUPPORT

Type of Algorithm Training

SIMULATION DATABASES
VIDEOS MODELS

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UC 2: Aircraft Dynamic Rerouting Support

Conceptual problem:

A **diversion** is often required during high workload situation like severe system failures, a sick passenger, or just for meteorological reasons (dense fog, storms, etc.)

If there are **variations to the standard arrivals** due to air traffic congestion, weather issues, maintenance operations at the airport, emergencies, etc. pilots become aware of these facts only when the Air Traffic Controller contacts them.

This Digital Assistant will **assist** the pilot during the descent, by **anticipating** the possible variations in the arrival routes, as well as providing them with different trajectories in case of emergency.

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UC 2: Aircraft Dynamic Rerouting Support

Digital Assistant (what the AI does):

- It may then **propose several options to the pilot**, presenting the risks and the benefits for each of them, letting the pilot have the final decision.
- Takes care of the Options in a **FORDEC** procedure.
- It re-evaluate dynamically the situation, keeping the pilot updated only with the precise information he needs to manage the situation
- Will assist the pilot during the descent, by **anticipating the possible variations in the arrival routes**
- In this sense, the assistant will show the **most likely options** that the ATC would suggest

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UC 2: Aircraft Dynamic Rerouting Support

- **Situation:** The pilot lands at an airport where he is not familiar with the descent and approach profiles. Or there is even a change in the approach route due to traffic or weather issues.
- **HARVIS assistant:**
  - is always **gathering information** about the performances of the AC (Fuel on board, trajectory, systems limitations, …), airport traffic, airport information (NOTAM, type of approaches usually flown, …), meteorological information, etc.
  - Will compute all the information and **suggest** the pilot different approach routes as the ATC would do, so that pilots can act accordingly with **anticipation**.
  - Will use a Visual and voice interface for the Human-Machine Interaction.

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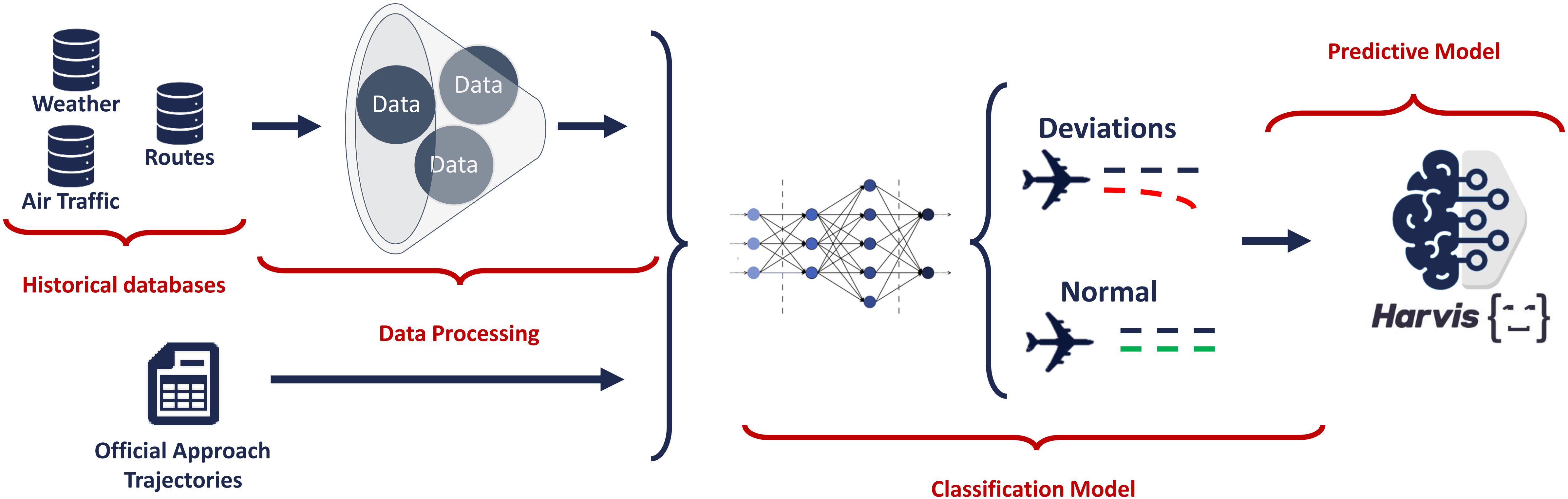
UC 2: Aircraft Dynamic Rerouting Support



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UC 2: Aircraft Dynamic Rerouting Support

Implementation:

- **2019:** Experiment definition
  - Explore Data Bases
  - Investigate Algorithms

- **2020:** Implementation
  - Data Base generation
  - Algorithm implementation
  - Experiment Validation

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UC 2: Aircraft Dynamic Rerouting Support

OBJECTIVE

SUPPORT REROUTING IN FLIGHT PHASE: APPROACH, TAKE OFF, EN-ROUTE

TYPE OF AI

ML,CC

EXPERT SYSTEMS

(RULES COMING FROM IA)

INPUT USED BY AI

PILOT (E.G. REAL TIME MONITORING)

A/C (E.G. SENSORS)

EXTERNAL (E.G. RADIO, GROUND)

Virtual pilot assistant

IA HMI

VISUAL

AUDIO (E.G. VOICE)

HAPTIC (E.G. VIBRATIONS GRAMMAR)

FACTS

OPTIONS

RISKS

DECIDE

EXECUTE

CHECK

TYPE OF SUPPORT

Type of Algorithm Training

SIMULATION DATABASES

VIDEOS MODELS

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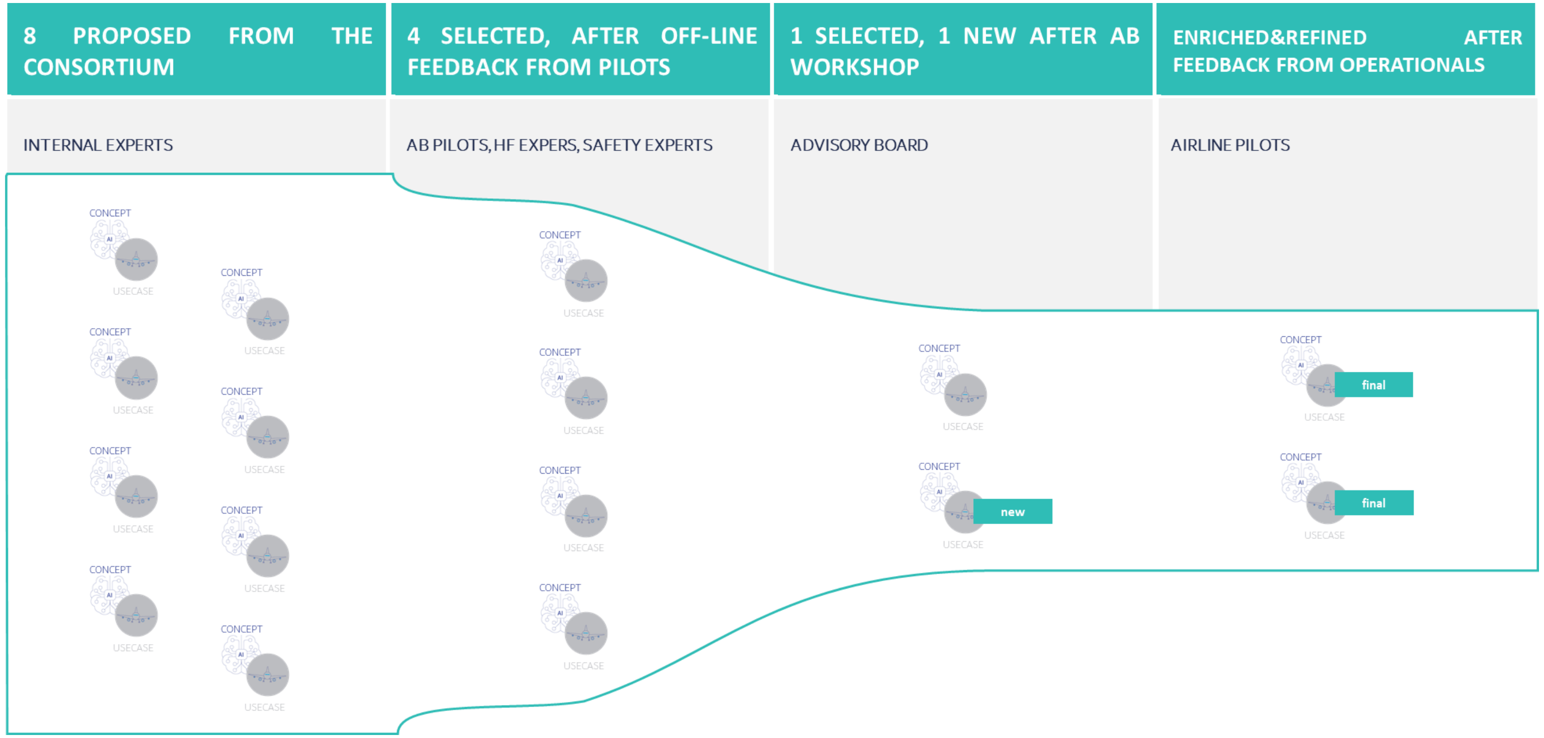
4. Validation Process: Approach

Even if the WP related to final validation starts at M20, the project is applying EOCVM approach and constantly validate the proposed Digital Assistant solutions from concept definition to final prototypes evaluation.

- **User centred**
  - Stakeholders are involved in the design process (Experimental scenario creation, HMI conception)
- **Iterative**
  - Initial validation of UCs
  - Validation of prototypes
  - Final validation



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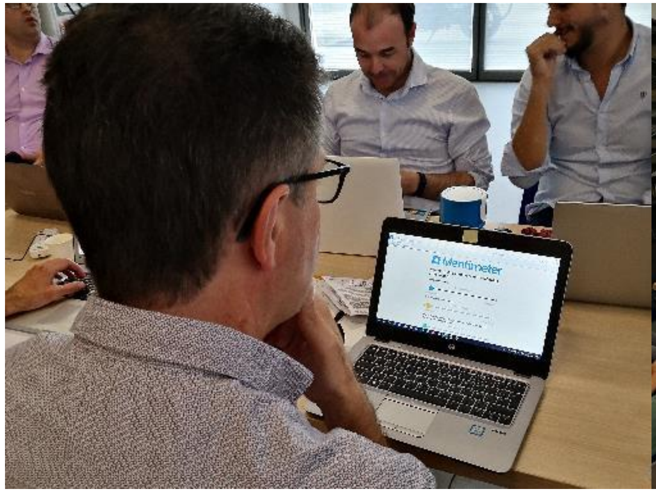
4. Validation Process: External Feedback

1st Advisory Board meeting

26th October, ENAC Facilities in Toulouse

Discussion led to the selection of two use cases that the project will investigate.

Participant members: pilots, safety experts, certification experts and instructors.



1st OPTICS 2 Roundtable (H2020)

HARVIS was presented in the roundtable aimed at answering the question: *How would you invest European research funding for Human Factors in aviation safety?*

High-level managers, representatives of research centres, ANSPs, airlines, airports, and pilots associations participated.

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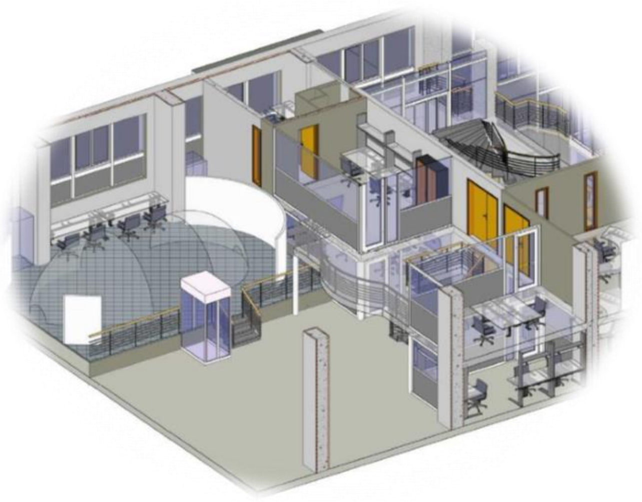
4. Validation Process: Facilities

ACHIL Platform at ENAC

- Dedicated to human factor studies
- A320 research simulator & connected ATC positions
- Permit high realism scenarios



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4. Validation Process: Final Validation for UC1/UC2

- Validation method
  - Pilots performing scenarios in ENAC simulator
  - Single pilot

- Measured indexes
  - Safety and HF
  - Performance (impact on operations)
  - Acceptability
  - Workload

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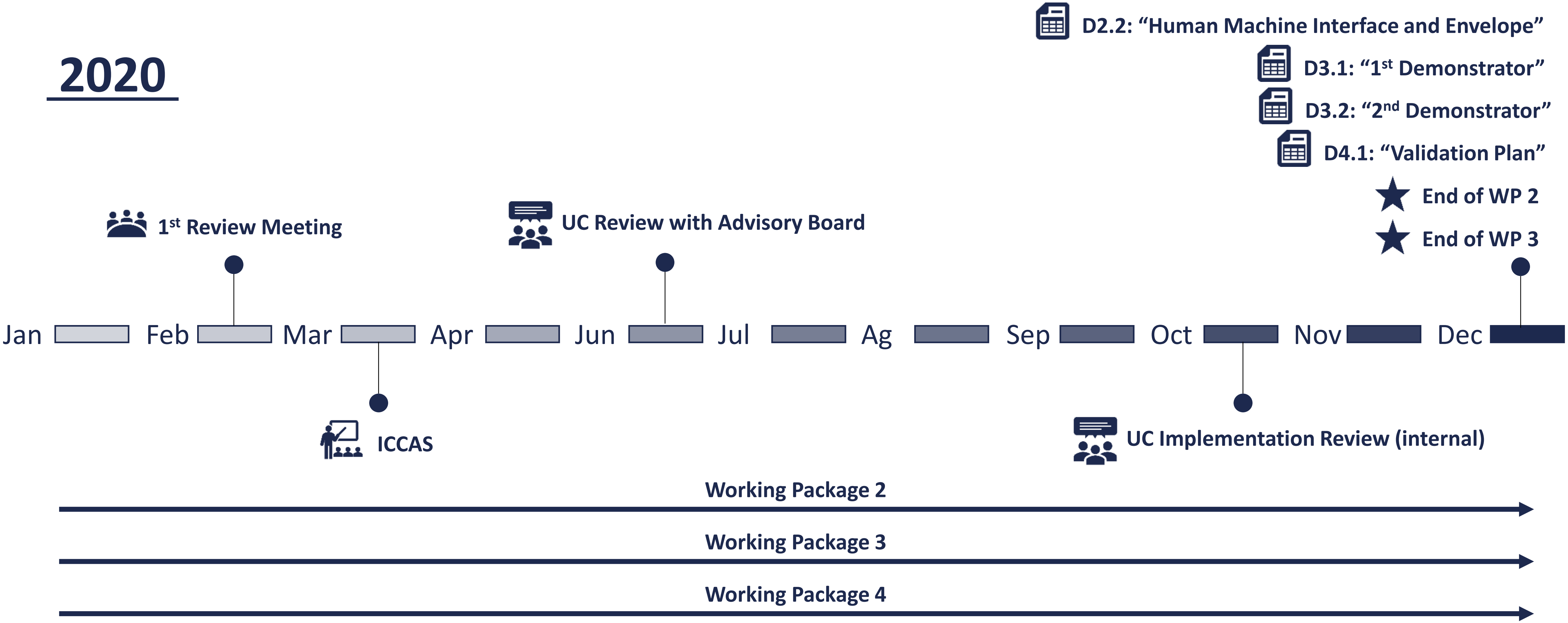
5. Next Steps



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Thank you very much for your attention

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