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Presentation of HARVIS Project

Presenter: HARVIS Partners
Date: 5\textsuperscript{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
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
1. Project Overview

• Main objectives:

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

• Partners:
1. Project Overview

- Advisory Board:
  - 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

- **End of WP 1**

- **Internal Workshop to Discuss Use Cases (ROME)**

- **D1.1: “State of the Art of CC algorithms”**

- **D2.1: “Analysis of potential CC aided tasks”**

- **Kick of Meeting**

- **Cluster Event (BRU)**

- **Working Package 1**

- **Workshop with Advisory Board (TOU)**

- **Working Package 2**

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2. Achievements in 2019

• Contents

Single-Pilot Operations (SPO)
Reduction commercial cockpit to a single pilot

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

Learning

Information

Interpretation (model)

Human Factors

Human Action

Automation

Balance

Adaptative/Cognitive HMI

Promote interaction between human and machine to achieve a “common goal”

Virtual Pilot Assistant Architecture

Multiple links used to support transfer of data and information between aircraft and various agents.
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 decision 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.
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
2. Achievements in 2019

Use cases elaboration process

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

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

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2. Achievements in 2019

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
2. Achievements in 2019

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
3. Use Cases

**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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3. Use Cases

UC1: Situation 1

Context: The AC has an unusual trajectory approaching stabilization point
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
3. Use Cases

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**Context:** The AC has an unusual trajectory approaching stabilization point

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

"GO-AROUND"
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.
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 (f.e. altitude).
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 (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.
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"
3. Use Cases

UC1: AI training (how the AI is developed)

🧬 Supervised ML based on pilot’s expertise

- Recorded or simulated atypical flight data
- Expert pilots

Data gathering → Go Around → Land → Rules Extraction

ML Algorithm

Expert System

Harvis
3. Use Cases

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

Generate different scenarios

Test on ENAC's Simulators

Validation

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3. Use Cases

**Virtual pilot assistant**

- **Input used by AI**
  - **Pilot** (e.g. real time monitoring)
  - **A/C** (e.g. sensors)
  - **External** (e.g. radio, ground)

- **Expert systems** (rules coming from IA)

- **Type of AI**
  - ML, CC

- **IA HMI**
  - **Visual**
  - **Audio** (e.g. voice)
  - **Haptic** (e.g. vibrations, grammar)

- **Type of support**
  - **Info acquisition**
  - **Info analysis**
  - **Decision making**
  - **Execution**

- **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 situations 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.
3. Use Cases

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.
3. Use Cases

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.
3. Use Cases

UC 2: Aircraft Dynamic Rerouting Support

- Weather
- Routes
- Air Traffic
- Historical databases

Data Processing

Data

Deviations

Normal

Classification Model

Predictive Model

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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
3. Working Packages Progress – WP 3

UC 2: Aircraft Dynamic Rerouting Support

**OBJECTIVE**
Support rerouting in flight phase: approach, take off, en-route

**INPUT USED BY AI**
- PILOT (E.G. REAL TIME MONITORING)
- A/C (E.G. SENSORS)
- EXTERNAL (E.G. RADIO, GROUND)

**TYPE OF SUPPORT**
- FACTS
- OPTIONS
- RISKS
- DECEIVE
- EXECUTE
- CHECK

**TYPE OF AI**
- ML, CC
- EXPERT SYSTEMS (RULES COMING FROM IA)

**IA HMI**
- VISUAL
- AUDIO (E.G. VOICE)
- HAPTIC (E.G. VIBRATIONS GRAMMAR)

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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
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
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

2020

Jan  Feb  Mar  Apr  Jun  Jul  Aug  Sep  Oct  Nov  Dec

- 1st Review Meeting
- UC Review with Advisory Board
- ICCAS

Working Package 2
Working Package 3
Working Package 4

D2.2: “Human Machine Interface and Envelope”
D3.1: “1st Demonstrator”
D3.2: “2nd Demonstrator”
D4.1: “Validation Plan”

End of WP 2
End of WP 3

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Thank you very much for your attention