CANSO WHITEPAPERS

Emerging technologies for future skies



Al in ATM: Enablers and use cases

Monday 12 April 2021 14:00 – 15:30 CEST



Moderator







Patrick Souchu Programme Director

DGAC/DSNA



ORGANISED BY EUROCONTROL

Al in ATM: Enablers and use cases Moderated by CANSO



Welcome to the third "FLY AI" webinar

FLY A WEBINARS

15 June 30 June 18 May Cyber for Al & Training & Al for Cyber Change Moderated by EUROCONTROL Sharing data for Management Al in aviation Moderated by IFATSEA/IFATCA Moderated by AIRBUS WEBINAR 24 FEBRUARY 2821 RESIDAR Partnering for AI in aviation Moderated by EUROCONTROL 28 April EASA AI 23 MARCH 2021 Trustworthiness Research and Guidance Moderated by Innovation in AI for EASA aviation 12 APRIL 2021 Moderated by the SESAR JU AI in ATM : Enablers & ATM use cases Moderated by CANSO





CANSO Strategic Technology Workgroup (STWG)









Members

Patrick Souchu, DSNA (Chair) Markus Klopf, Frequentis (Vice Chair) Michele Carandente, Aireon Alex Brooker, Cirium Martin Bowman, Deloitte UK Rüdiger Schwenk, DFS Ben Stanley, Egis Mercedes Puzio, EANA Cristiano Cantoni, ENAV Luigi Mazzucchelli, ENAV

Thomas Reifert, Hensoldt Midori Tanino, FAA Derrick Grant, JCAA Fabian Taylor, JCAA Kyotaro Harano, JANS Mimi Leone, MITRE Julian Titmuss, NATS Rui Guerra, NAV Portugal Nono Simoes, NAV Portugal Tomasz Klosowicz, PANSA Jörg Kilpert, Rohde & Schwarz
Tadas Rinkevicius, SE Oro Navigacija
Danilo Pisciottu, skeyes
Luc Lallouette, Thales
Todd Donovan, Thales
Rob Morris, To70
CANSO:
Michelle Bishop, Director Programmes
Bianca Knoll, Project Manager STWG

Objectives of Strategic Technology Workgroup



Produce an overview of the current state of technology deployment and implementation planning of various technologies at regional and global level;



Undertake an **assessment of the potential impact of new technologies** on ANSPs and ATM performance;



3

Provide input into a **coordinated work plan for CANSO's Standing Committees and regional working groups** dealing with particular aspects of technological deployment and implementation planning.

D#2: Creation of seven white papers regarding new technologies and their strategic impact on aviation/ANSPs



OUR PANELLISTS TODAY

CANSO WHITEPAPERS Emerging technologies FLY A WEBNARS

ORGANISED BY EUROCONTROL



Patrick Souchu

Programme Director. On behalf of CANSO.



Béatrice Pesquet-Popescu

Research & Innovation Director



Zoltán Molnár

Safety and Risk Management Expert



HungaroControl



Manager European

ATM Coordination &

Eduardo

Garcia

Safety



Firdu Bati

Manager, Analytics & New Entrants





Michael Poiger

Senior Lead Expert, Control Room Consulting





Al in ATM: Enablers and use cases

Speaker







Beatrice Pesquet-Popescu Research & Innovation Director

Thales

Outline of the White Paper & Webinar





Infrastructures for Data

Common Data Infrastructures Initiatives





Explainability

Explainability Challenges

"Black-box" model

- > Correlation does not imply causation:
 - ML models rely on correlation
 - Explanations need causality

Prove the explanation is reliable and correct



(a) Husky classified as wolf





Explainability Challenges

Meaningful (understandable) explanation for:

- Data scientist, SW dev
- End user (ATCO, pilot, maintenance operator)
- Regulation authority
- Accident investigator



WHAT PART OF "MEOW" DON'T YOU UNDERSTAND?

Explanation Accuracy: The explanation correctly reflects the system's process for generating the output

Knowledge Limits: The system only operates under conditions for which it was designed or when the system reaches a sufficient confidence in its output

Explainability, safety and HMI

Link with Learning Assurance: high level and low level features

Link with **operational monitoring**: OOD, performance

Link with Human Factors considerations

Link with **data recording and traceability** (inputs, internal states, outputs, derived features)





Certification Aspects

EUROCAE WG114 / SAE G-34 (Al certification in Aviation)

Objective: establish common standards, guidance material and any related documents required to support the development and the certification/approval of aeronautical safety-related products based on Altechnology <u>G-34/WG-114 focuses on</u> implementation and certification related to Al technologies for the safer operation of aerospace systems and aerospace vehicles.

- <u>G-34/WG-114 (comprised of 500+ members)</u> promotes and standardizes Artificial Intelligence in the entire aviation ecosystem (both Airborne and Ground) addressing both manned and UAS.
- <u>G-34/WG-114's Global contributors</u>: Boeing, Airbus, ATR, Embraer, Textron, Gulfstream, Dassault, Mitsubishi, Lockheed, Northrop Grumman, GA-ASI, HondaJet, Daher, IAI, ICAO, FAA, EASA, TCCA, ANAC, DGAC, CAA UK, CAA NZ, JCAB, ENAC, FOCA, DOD, EDA, Lilium, Aerion Supersonic, Amazon, DXC, SAP, IBM, Joby, EUROCONTROL, NASA, EDA, Honeywell, Collins, Thales, GE, P&W, RR, Safran, Raytheon, BAE, Elbit, L3Harris, Iridium, Japan Manned Space Systems, FedEx, UPS, AF-KLM, Nodein, Lufthansa, Audi, Toyota, IATA, Leonardo, Leidos, NVIDIA, Intel, Saab, Volocopter, ANSPs, Skyguide, Searidge, Woodward, Vertical Aerospace, Diehl, ADB Safegate, AVSI, ANSYS, BNAE, Copenhagen Airports, D-Risq, Daedalean AI, KIAST, Infosys, Afuzion, Patmos Engineering, QinetiQ, RelmaTech, Rockdale Systems, DLR, drR2, Federated Safety, MathWorks, SRI, Oak Ridge National Lab, etc.

Works In Progress and deliverables:

- AS6983 Process Standard for Development and
 - Certification/Approval of Aeronautical Safety-Related Products Implementing AI
- AIR6987 Artificial Intelligence in Aeronautical Systems: Taxonomy
- AIR6988 Artificial Intelligence in Aeronautical Systems: Statement of Concerns
- AIRxxxx Artificial Intelligence in Aeronautical Systems: Use Cases Considerations
- For more information and/or membership registration, contact: jordanna.bucciere@sae.org and/or anna.guegan@eurocae.net.

SAE INTERNATIONAL

Joint International Committee on Artificial Intelligence in Aviation Ecosystem



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EUROCAE

WG-114/G-34 Roadmap



Deliveries

- SOC (Statement of Concerns) ER/AIR
- Taxonomy, Use Cases ER/AIR
- Std Issue 1: ML (Offline Learning) ED/AS
- Std Issue 2: Other AI Technologies ED/AS





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Speaker







Zoltan Molnar Safety and Risk Management Expert

HungaroControl



Safety Aspects

Software safety assurance

- ED-153 Guidelines for ANS Software Safety Assurance
- ED-109A/DO-278A Guidelines for CNS/ATM Systems Software Integrity Assurance

Assumptions:

- The algorithm is fully explainable
- Traceability of the requirements is provided
- Fulfilment of these requirements can be justified

Effect Severity	1	2	3	4
Likelihood of generating such an effect				
Very Possible	SWAL1	SWAL2	SWAL3	SWAL4
Possible	SWAL2	SWAL3	SWAL3	SWAL4
Very Unlikely	SWAL3	SWAL3	SWAL4	SWAL4
Extremely Unlikely	SWAL4	SWAL4	SWAL4	SWAL4

ED-153 -Guidelines for ANS Software Safety Assurance 3.6 Software Assurance Level

Challenges of AI safety

Algorithm

- Almost every popular ML method contains a "black box" part (explainability issues)
- Decisions are based on unexplainable patterns

Data

- Even the most robust ML algorithm's performance is highly dependent on the training dataset
- Inadequate datasets training, test and validation

Other aspects

- Learning process can be the subject of bias or variance
- Reinforcement learning is a separate topic



Potential solutions

Scoping & Requirement definition

What we expect from the system? How critical is the application?

Data selection & preparation



Safety assurance of the datasets (correct and complete, non-nominal scenarios)

Model selection



Enhancing explainability – utilization of more explainable models depending on the safety criticality, explainable AI (XAI) techniques

Training



Training assurance (optimize the model, hyperparameter tuning)

Verification & Validation

Pre-defined acceptability parameters – e.g. ratio of false negatives/positives Validation on component, sub-system and functional system level

Safety & resilience

"Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions." – ECTL White Paper

- Promising performance of narrow AI in numerous fields might accelerate automation in ATM
- Performance of ML applications shall support safe service provision even in rare and non-nominal situations
- Human machine interaction shall be assessed to keep or enhance the safety level and the resilience of the functional system
- Performance monitoring (monitoring criteria) is very important after implementation



Al in ATM: Enablers and use cases

Speaker







Eduardo Garcia Manager European ATM Coordination & safety

CANSO



Human-Machine Collaboration

Human-Machine Collaboration

• Al can **complement and augment** human capabilities

MABA – MABA Men Are Better At – Machines Are Better At





[Parasuraman's model]

Human-Machine Collaboration

 Roles and responsibilities of human actors in the functional system will change with the introduction of AIbased models Keeping the human in the loop is essential in a synergic human-machine collaboration and contributes to the resilience of the functional system





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Use Cases

Speaker







Firdu Bati Manager, Analytics & New Entrants

FAA



Safety Enhancements

Al Application Area – Air Traffic Safety

- Several application areas in air traffic safety management and risk analysis
 - Automation of repetitive activities
 - Risk/event detection
- Example use cases:
 - Key performance indicators
 - Comprehensive Risk Metrics
 - Event categorization type & severity
 - Anomaly Detection

Safety Key Performance Indicators (KPIs)

Existing KPI Collection methods:

- Through manual reporting or
- Detected through rule-based deterministic algorithms that are rigid, tend to generate a higher rate of false positives



Huge potential to leverage ML to automate KPIs detection - large amount of data exists. ML automations provide:

- Scalable solutions
- Stable detection mechanism consistent with existing knowledge encoded in data

Recently FAA Air Traffic Safety organization has demonstrated a voice-based ML model to detect UAS encounters with manned aircraft which provided a highly accurate result

Risk Metrics

- Aggregate Metrics provide comprehensive tools to monitor the safety performance of complex systems like air traffic control.
- Developing metrics is a complex process which involves prediction of risk and identification of different outcomes of undesired safety events



FAA surface safety Metric

Event Count & System Risk Index

- Models that support such metrics need to process data from diverse sources.
- For instance, for a surface metric:
 - Identify relevant events like runway excursions, runway incursions, and taxiway incidents
 - Assign appropriate numerical indices proportional to the severity of each outcome
- A fatality, injury, and aircraft damage will have a corresponding weight for each outcome
- Incident weight is based on its probability of becoming an accident.

Event Classification – Type and Severity

- A key activity of SMS is to proactively collect and analyze safety events
- The two primary data collection means:
 - A reporting system and
 - Automated capturing of rule violations and close encounters
- The process requires the categorization safety events by:
 - Operation types and environments
 - Consequences & Severity
- The manual classification of these events is not only laborious, but it is also error prone.
 - NASA ASRS processes a very small amount

- ML can enhance managing safety events
- Large amount of data to support supervised learning models
- These models can categorize not only the type of events but also severity levels



Runway Incursion Severity Categorization

FAA Air Traffic Organization model to classify runway incursions into four severity categories (A, B, C, D). The identification process largely relies on event descriptions as reported by pilots and controllers.

Anomaly detection

- Large majority of data in aviation safety not annotated
- Overwhelming amount of the operations data in aviation is normal
- Supervised learning is impractical due to the difficulty of rare event modelling
- Anomaly detection is the most viable alternative





- One application of anomaly detection is to identify those that manifest different characteristics
- Domain experts can validate once a smaller subset of potentially risky flights is identified
- NASA recently demonstrated this application on several airports in the U.S National Airspace System using a kernel method

Flight Trajectory Case Study: representation of a case study from Munich to London – Taken from Detecting Flight Trajectory Anomalies and Predicting Diversions in Freight Transportation



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Beatrice Pesquet-Popescu Research & Innovation Director

Thales



Increased Automation through Conflict Resolution Advisories



TOWARDS ATC AUTOMATION WITH SMART ADVISORIES

24 54544

AFR5678 368 cfl

20'R/25NM

CTN654 = A320 368 c/l

1415-200 14100-000 DLH38 22 THY33 19 RCH13 30 G CTN65 28 CTN65 Croatia 654, turn right of 20 degrees for 25 NM due to traffic



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Speaker







Michael Poiger Senior Lead Expert, Control Room Consulting

FREQUENTIS AG



Voice Recognition

Definition (What is Voice Recognition?)

Voice Recognition

Speech Recognition

- Ability to transcribe words and sentences
- Language Identification
 - Ability to identify spoken language
- Speaker Recognition
 - · Ability to identify speaker
 - Using the characteristics of their voice (voice biometrics)

- Supported by AI
- Training of the speech model
- Interpretation of context
- L Automation support based on intelligent decisions

Identify the benefit

Operational Improvement Analysis – Frequentis aware® method



Operational Benefits vs. Efforts

Identification Measures	Capture the process	Optimize the process	Implement the change	
Target definition	Information stream analysis	Information stream optimization	Automation Support	
Definition of the Objectives based on user scenariosDefinition of KPIs	 Visualization and description of the operational process information streams 	 Elimination of the gaps Identify improvement points for automation support 	 Design optimised business- and user-centric information stream Enable operational benefits 	

Supportive areas of Speech Recognition



Technical Challenges of speech recognition

- Recognition Rate *how to trust the system?*
 - Never 100%
- Error Rate shall be limited to a minimum *how to prevent?*
 - Disrupt operator and increase workload
- Audio Quality (e.g. pilot conversation) how to recognise?
 - Poor audio quality
- Availability of Trainings data *how to train the system?*
 - Huge amount of trainings data needed

Al support to tackle technical challenges

Recognition Rate

- Machine Learning helps to improve the speech recognition to a maximum
- Well integrated into the user interface as an assistant tool helps to tackle the best symbiosis

• Minimise Errors

- Understanding the context supported by Natural Language Processing helps to reduce recognition errors
- Improvement due to contextual information provided by intelligent decision support
- Audio Quality (e.g. pilot conversation)
 - Improvement of audio quality
 - Pattern recognition to improve recognition rates within audio streams
- Availability of Trainings data
 - Al / Machine Learning support to process and elaborate trainings data.

Research & Conclusion

PAPER: CANSO Strategic Technology Workgroup (STWG) Artificial Intelligence – Enablers and Use Cases

Beatrice Pesquet (Thales), Firdu Bati (FAA), Alfonso Nicotera (IDS AirNAv), Adam Gyarmati (Hungarocontrol), Eduard Gringinger (Frequentis), Zoltan Molnar (Hungarocontrol), Roland Tichy (Hungarocontrol), Maria Tamm (EANS), Julian Titmuss (NATS)



Automatic Speech Recognition for ATCO support (A FLY AI Webinar, Harmut Helmke)



Next Generation Safety (NGS)

Al with focus on automation of communication, monitoring of the situation and corrective measures necessary for the situation

- Other Related Papers
 - Ontology for Transcription of ATC Speech Commands of SESAR 2020 Solution PJ.16-04
 - Machine Learning of Controller Command Prediction Models from Recorded Radar Data and Controller Speech Utterances
 - Cost Reductions Enabled by Machine Learning in ATM
 - Characterizing National Airspace System Operations Using Automated Voice Data Processing



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Questions

and

Answers

Launch of the Artificial Intelligence white paper April 2021







the next "FLY AI" webinar on:

EASA AI Trustworthiness Guidance: paving the way to safety-related AI certification28 April, 15:00-16:30 CET

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Thank you

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