Welcome to the EASA AI Days High-Level Conference !

16th May 2023

EASA

Welcome to the EASA AI Days High-Level Conference !

Janet Northcote – EASA Head of Communications

EASA

Opening Speech
AI in Aviation: Applications and Opportunities

Rachel Daeschler – EASA Certification Director

EASA

Keynote speech
EU AI regulations

Antoine-Alexandre André – DG CNECT A/2
European Commission – Policy and Legal Officer

EASA

European Commission

SHAPING EUROPE'S DIGITAL FUTURE

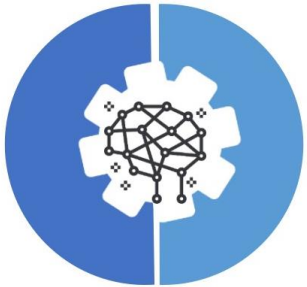
The AI Act and the standardization process

Antoine-Alexandre André – DG CNECT A.2

Big picture

AI is an opportunity…

- For consumers
- For business
- For the common good



…but creates certain risks

- For the safety of users
- For fundamental rights

Commission's AI Package April 2021

- Communication on fostering a European approach to AI
- Review of the Coordinated Plan on Artificial Intelligence
- Proposal for a regulation laying down harmonised rules on AI (AI Act)

European Commission

Proposal for a Regulation on AI

Horizontal legislation laying down uniform rules for AI in the EU market

- "Classic" internal market rules applicable to the **placing on the market, putting into service and use of** AI systems
- Two main objectives:
  - **create a single market for trustworthy AI in EU**
  - address **risks to safety and fundamental rights**
- Consistent with and complementing existing EU and national law (e.g. employment, data protection)

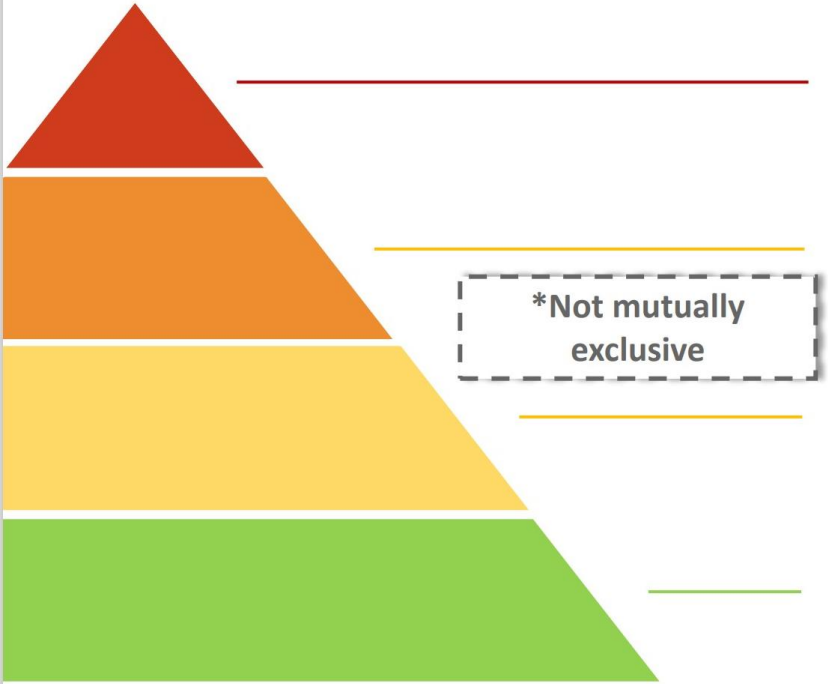
Innovation-friendly and risk-based legislation

- Provide **legal certainty** to operators and stimulate **trust** in the market
- No overregulation: designed to intervene only where strictly needed following a risk-based approach

Creates a level playing field for EU and non-EU players

- Applicable independent of origin of producer or user

Risk-based approach



*Not mutually exclusive

Unacceptable risk
e.g. social scoring, remote biometric identification in publicly accessible spaces

Prohibited

High risk
e.g. recruitment, medical devices

Permitted subject to compliance with AI requirements and ex-ante conformity assessment

'Transparency' risk
'Impersonation' (e.g. chatbots)

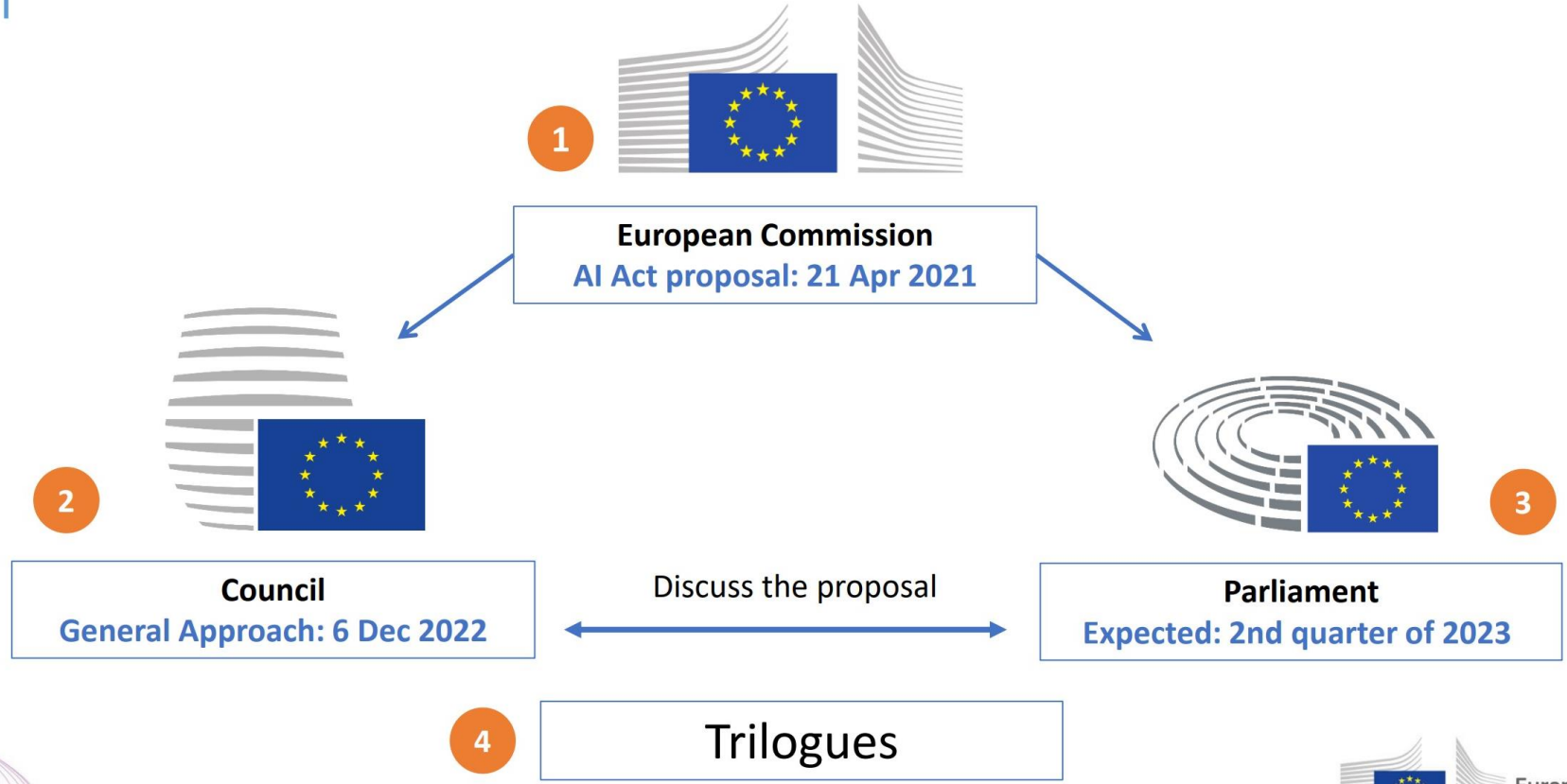
Permitted but subject to information/transparency obligations

Minimal or no risk

Permitted with no restrictions

European Commission

Ordinary legislative procedure within the EU



European Commission

The AI Act: a NLF legislation (1)

AI Act is a New Legislative Framework (NLF) type legislation

- **Requirements** are described in the legislation
- **Technical solutions to comply with the requirements** can be provided by **standards**, other **technical specifications** or **be developed** in accordance with general engineering or scientific knowledge

Annex II relates to the so-called Old Legislative Framework: **section B lists the Union harmonisation legislation to which the AI Act does not directly applies** (but **requirements will apply in the future**, when adapting existing rules) → including Regulation (EC) No 300/2008 and Regulation (EU) 2018/1139 **covering aviation**

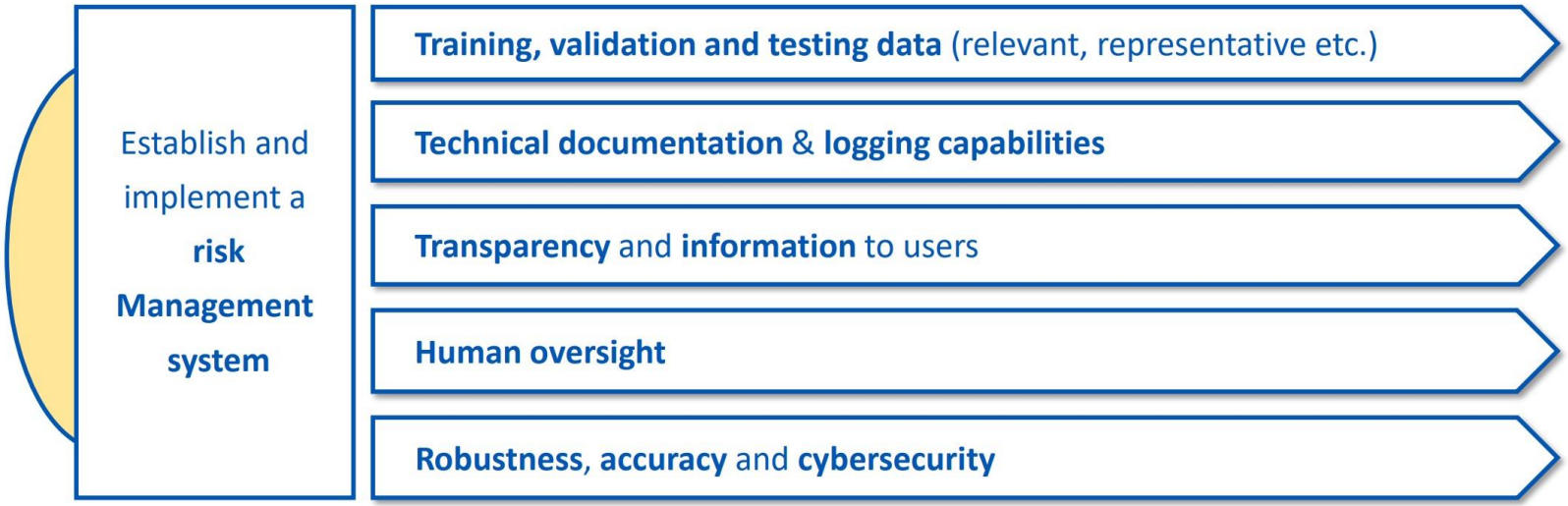
The AI Act: a NLF legislation (2)

Objective: help to remove obstacles to free movement of goods in the EU internal market, while producing an environment which promotes international trade

- **Flexibility for producers:** can use technical solution of their choice
- **No need of regular adaptation of the law to technical progress**
- **European harmonized standards:**
  - reg. (EU) 1025/2012 on European standardization
  - not mandatory, but will enable harmonisation of practices across EU and facilitate demonstration of compliance by operators
  - presumption of conformity with relevant requirement - Art. 42(1)
  - issued by European Standardisation Organisations (CEN/CENELEC & ETSI) on mandate by Commission
  - agreements between ESO and International Standardization Organizations (e.g. ISO/IEC and ITU)

EC activities related to AI standardization (1)

- **Horizontal** harmonised standards will have to be produced to **operationalize requirements** of the AI Act
- Requirements for high-risk AI systems cover the **following areas**:



EC activities related to AI standardization (2)

Objective: To have a large subset of harmonised standards available 3-6 months before the date of application of the future AI Act

Main activities up to date:

- **Mapping research** about relevance of ongoing standardisation activities
- **Strong engagement** with European and international standardisation organisations and direct participation in certain strategic standardisation activities
- **Supporting role** to ensure good cooperation between horizontal and vertical standardisation outcomes
- **Preparation of** first standardisation request (to be adopted very soon)
- **AI chosen as a test-case** to improve the standardisation system: driver for larger mobilisation of stakeholders and experts

Key elements AI standardisation request

- **Timeline:** deliverables by 30 April 2025
- **Addressed to CEN/CENELEC**, however work of ETSI to be taken into account and process to be established for leveraging on ETSI experience and work
- **Representation and participation** of the relevant stakeholders, including SMEs, and societal stakeholders
- **Fundamental rights and data protection** to be taken into account
- **Leveraging on the existing knowledge and ongoing efforts at the EU and international levels**. This however should not bring any prejudice to the full alignment of standards with EU values and specificities *(Article 2 (c); recitals 8 and 16)*

Thank you

For any questions: antoine-alexandre.andre@ec.europa.eu

European Commission

Keynote speech
AI trustworthiness

Dr. Nicholas Asher – IRIT / ANITI Research Director

EASA

AI and EASA

Nicholas Asher

EASA
European Union Aviation Safety Agency

ANITI
Université Fédérale
Toulouse Midi-Pyrénées

Artificial Intelligence

Artificial intelligence relies on ``intelligence'' which is based more on family resemblance than on a strict definition

AI an attempt to automatise tasks that humans often take as marks of intelligence

- conversation
- planning, scheduling

A huge growth area for industry

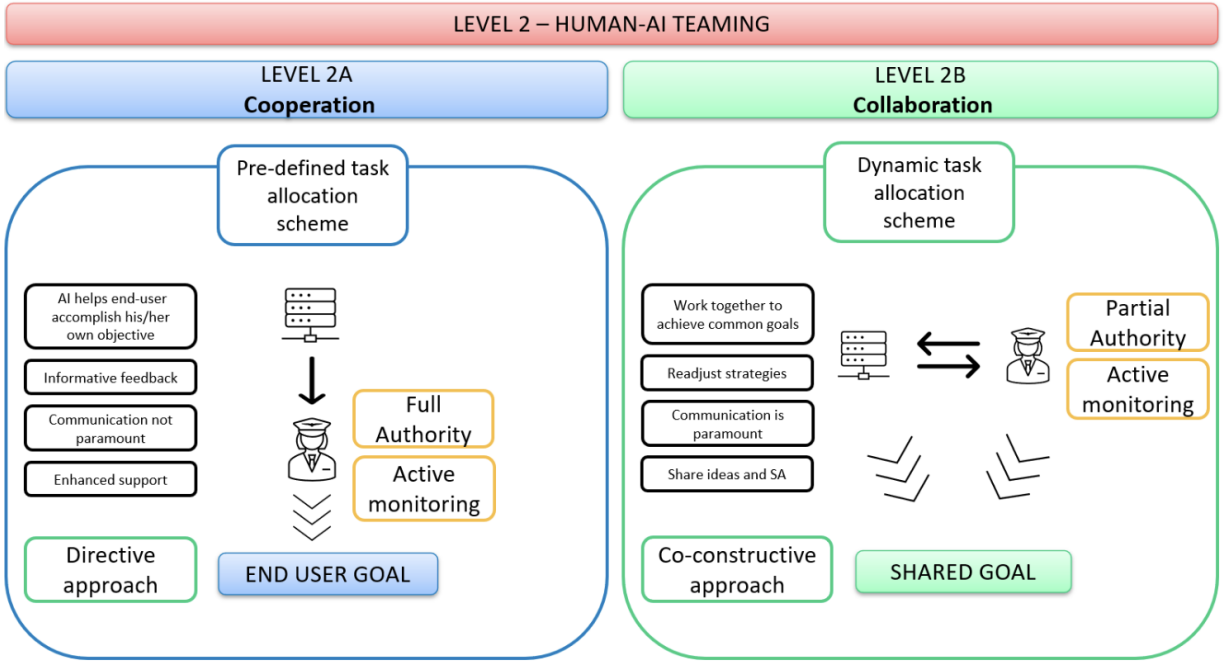
potential and considerable risks

AI solutions possible only with adequate level of trust from operators and impacted public (passengers)

EASA
European Union Aviation Safety Agency

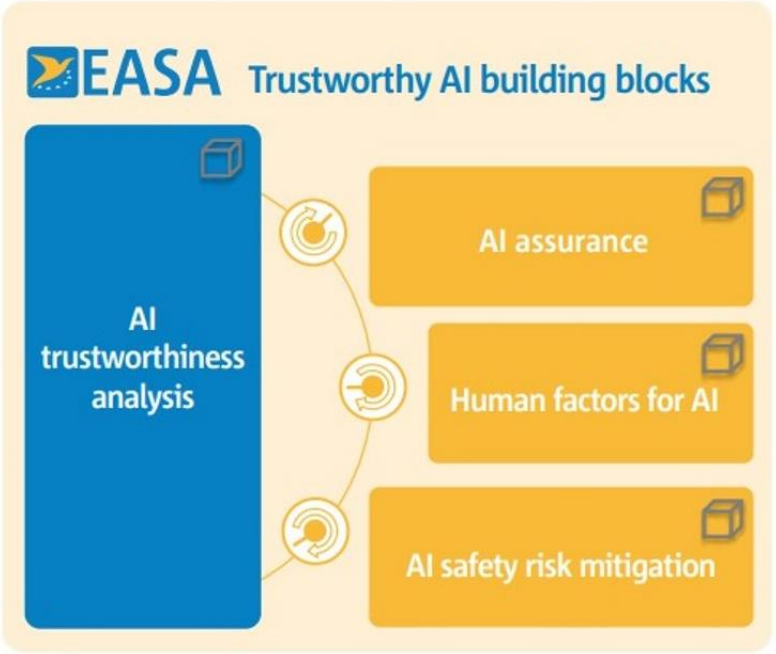
Levels of AI involvement

- Level 1 Artificial Intelligence (‘assistance to human’)
- Level 2 Artificial Intelligence (‘human-machine collaboration’)



EASA
European Union Aviation Safety Agency

3 **requirements** for AI trustworthiness



- technical objectives - what the system does and how well it does it
- human-centric objectives – human/system interactions for safe operations
- ethical and liability objectives-acceptability of AI to end users (flying public)

EASA
European Union Aviation Safety Agency

The challenges for trustable AI level 2

- Guarantees of performance, robustness
- Interpretability for the user (pilot, controller)
- Fluid and secure interactions between AI system and human

EASA
European Union Aviation Safety Agency

A closer look at explainability/interpretability

- symbolic formalization model based explanation as deduction
  provable guarantees, strong interpretability
  but difficult to extend to large DL models

- Particular challenges of interpretability in transformer models
  even using statistical methods (heat maps, etc.)

- Counterfactual model based explanations, generalizable
  to large DL models, intuitive explainability, can use both
  statistical and logical methods

EASA
European Union Aviation Safety Agency

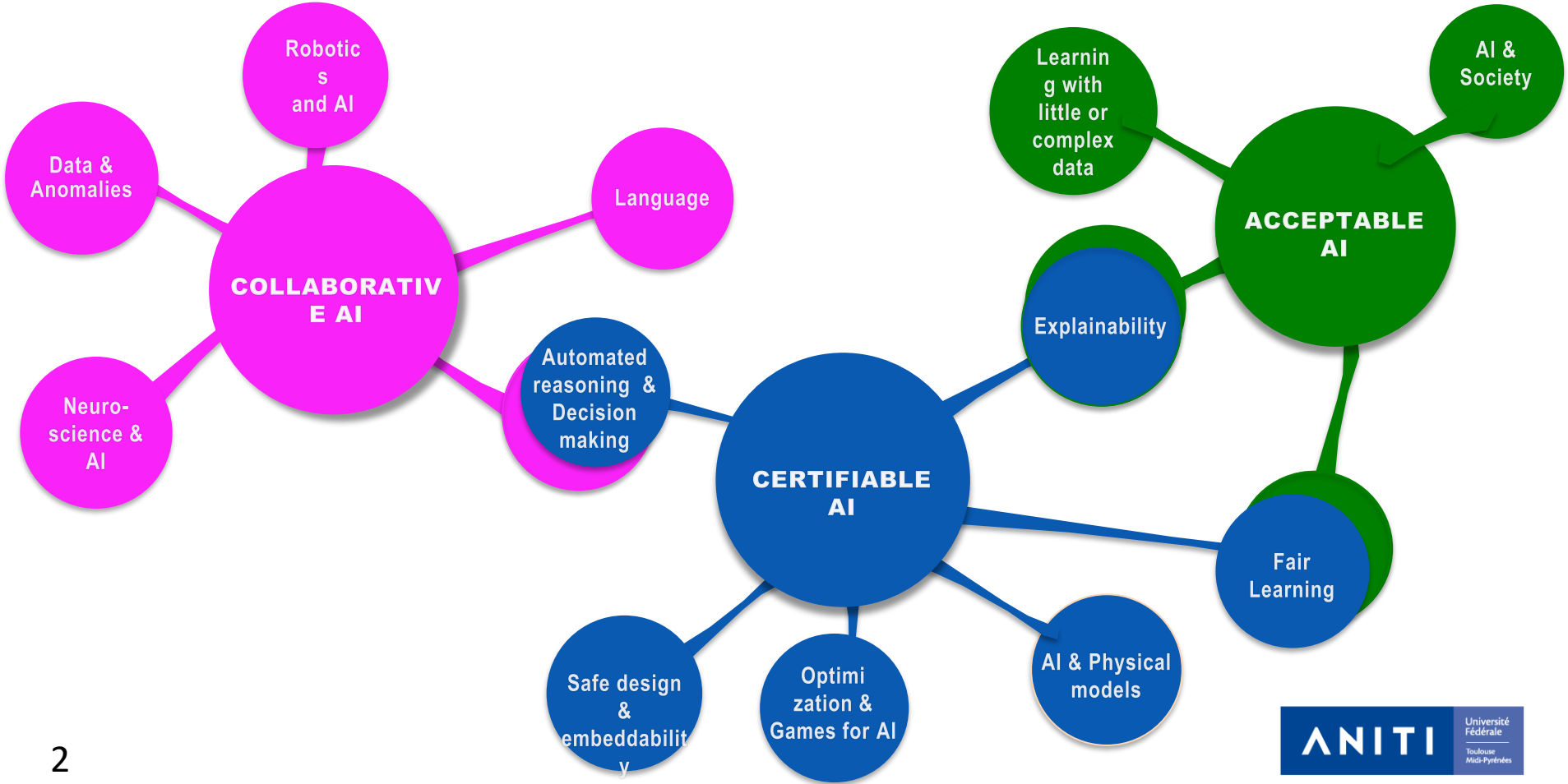
A closer look at conversational assistants and cobots

- Massive progress in the last year using transformer architectures (GPT)
- Fluent conversation and adaptable to many NLP tasks
- Problems with reasoning and hallucinations
- Fixing these problems is not easy but we know much more about these models than before. New types of loss functions and training.

Embedding these models in a multimodal framework that can add constraints to the LLM

European Union Aviation Safety Agency

AI in ANITI: a resource for EASA and aviation industry



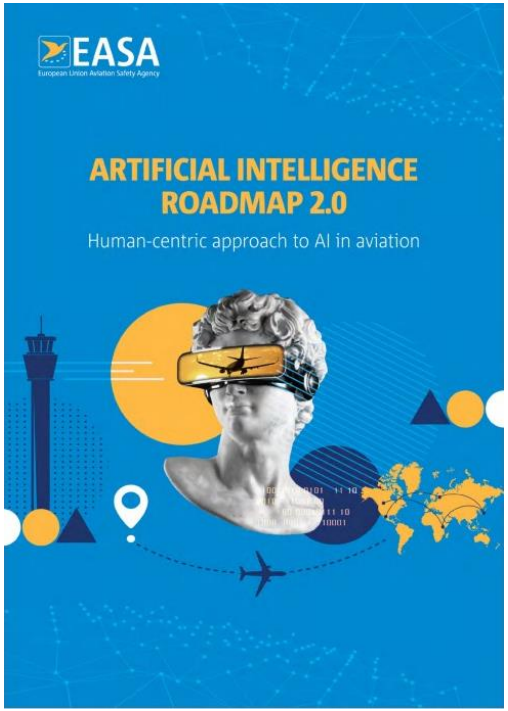
ANITI people

Unveiling EASA AI Roadmap 2.0

Guillaume Soudain – EASA AI Programme Manager

EASA

AI Roadmap 2.0 : Ariadne's thread



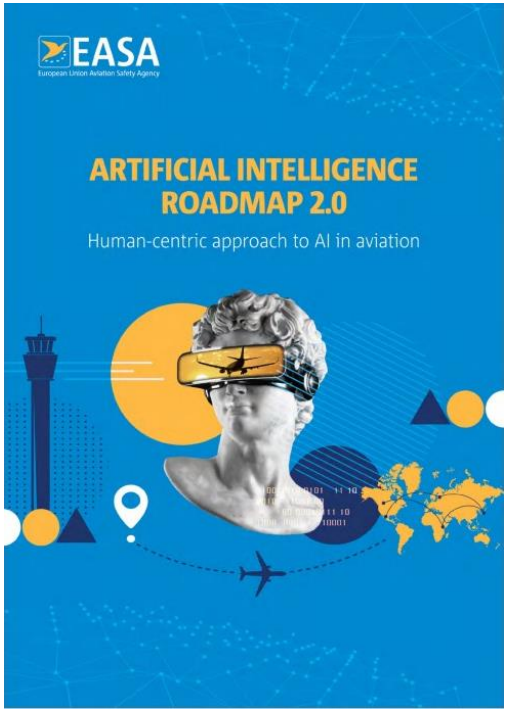
Looking back : EASA AI Programme activity

Re-scoping : a wide range of AI techniques

Deep diving : AI trustworthiness concepts

Moving forward : updated list of priorities

AI Roadmap 2.0 : Ariadne's thread



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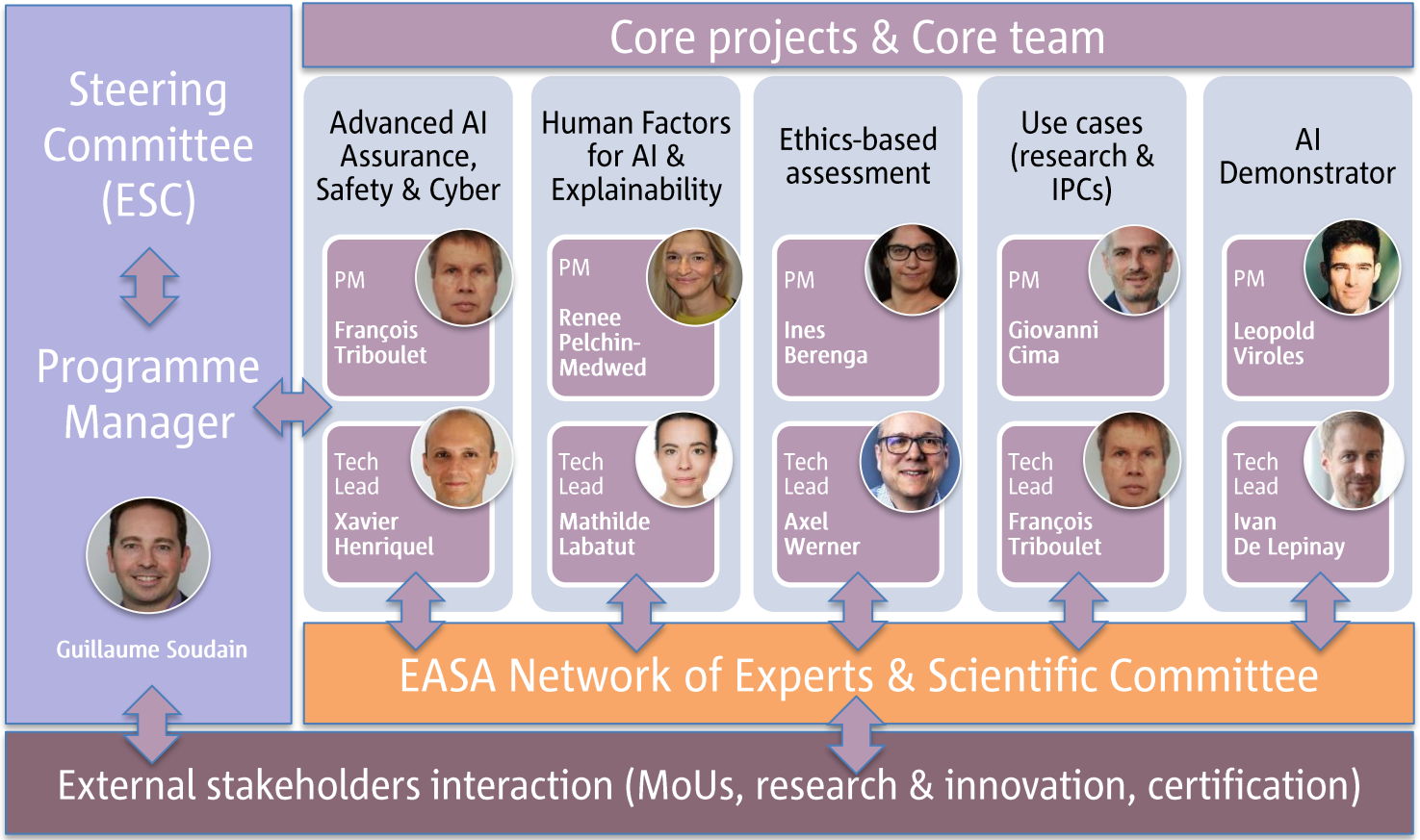
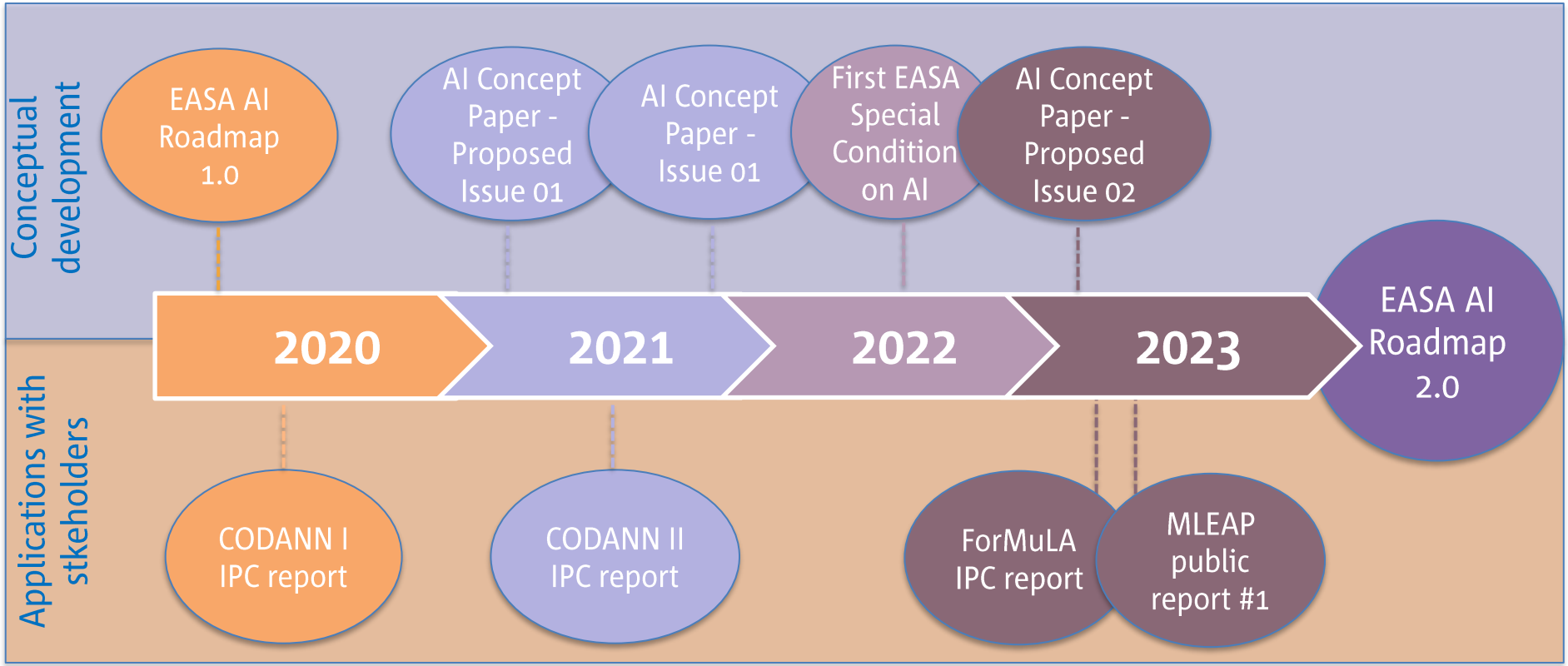
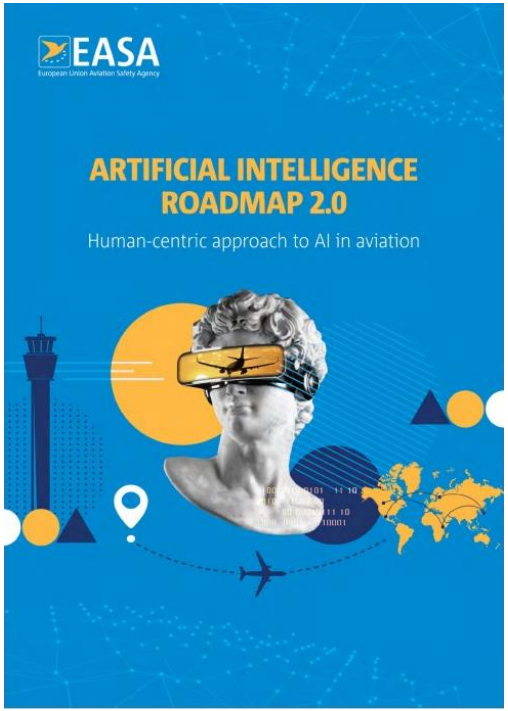
EASA AI programme : structure & core team



EASA AI Roadmap deliverables so far



AI Roadmap 2.0 : Ariadne's thread



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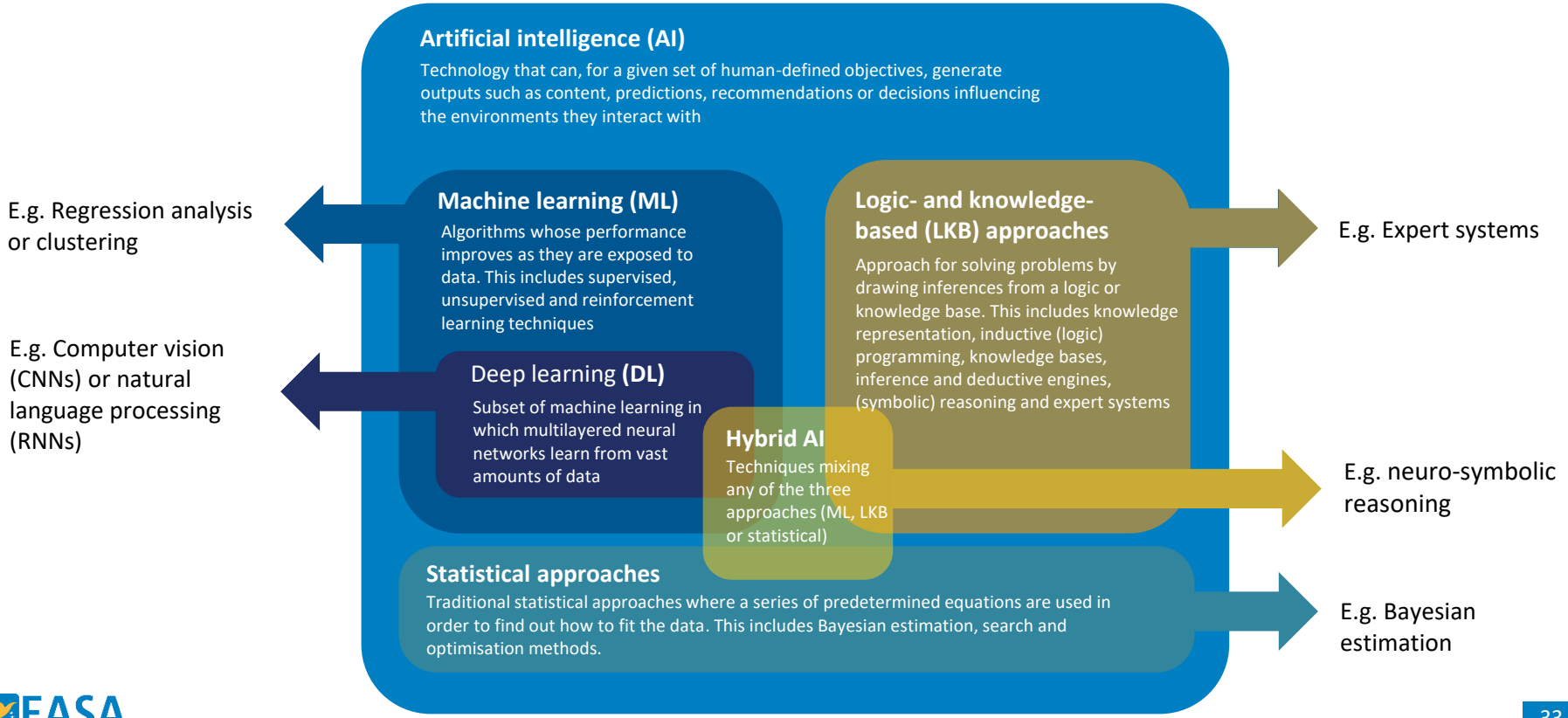
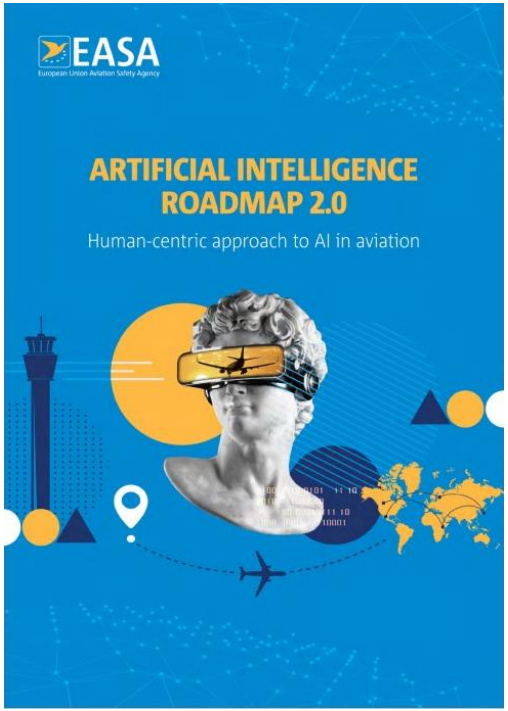
Scope of technology covered by Roadmap 2.0



AI Roadmap 2.0 : Ariadne's thread



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Main challenges related to AI

Data management

- Development assurance frameworks not adapted to learning and inference
- Difficulty in keeping a comprehensive specification through data and knowledge

AI model assurance

- Addressing model bias and variance optimisation in the various steps of the AI assurance process
- Elaborating pertinent guarantees of AI models and on the absence of unintended behaviour

AI explainability

- Coping with limits in predictability and explainability of the AI application behaviour

Human-AI teaming

- Managing shared operational authority in novel types of human-AI interaction
- Dealing with adaptivity of the AI application

EASA response:
the AI trustworthiness concept

Main AI trustworthiness concepts

Ethics-based assessment

Continuous safety risk mitigation

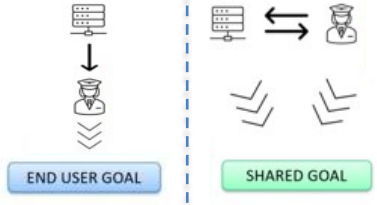
DEV OPS

AI explainability

Learning assurance

Level 1 AI Cognitive Human assi

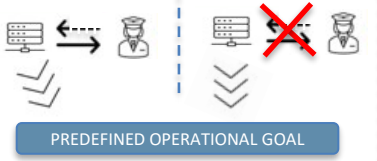
Cooperation (2A) | Collaboration (2B)



Human-AI teaming

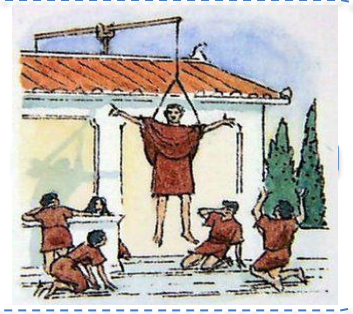
Level 2 AI Human-AI teaming

Supervision (3A) | Adv. automation (3B)



Human-AI teaming

Level 3 AI Advanced automation



Level 3C AI? Autonomous AI

?

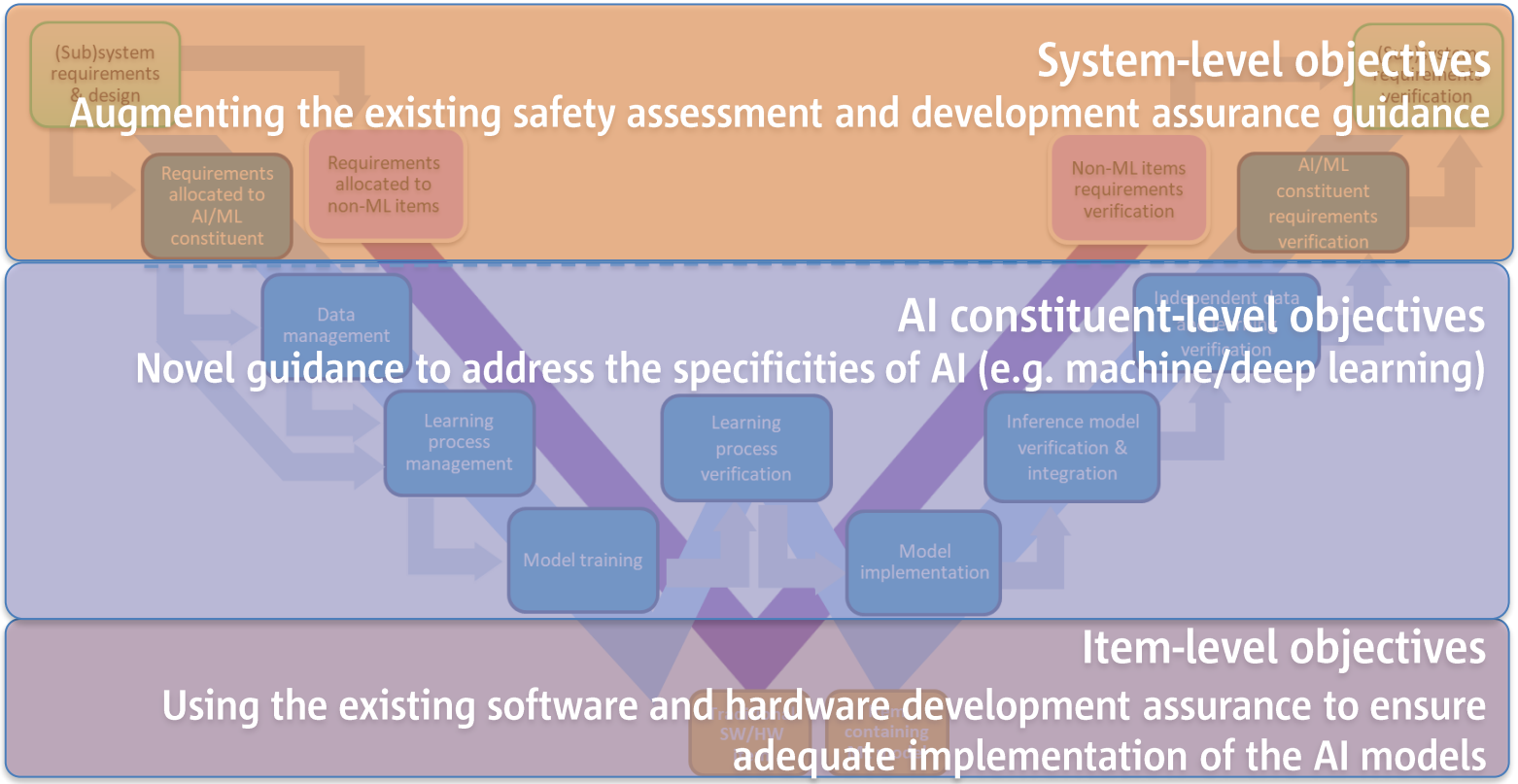
Daedalean Traffic Detection

Singapore ATMRI CD&R

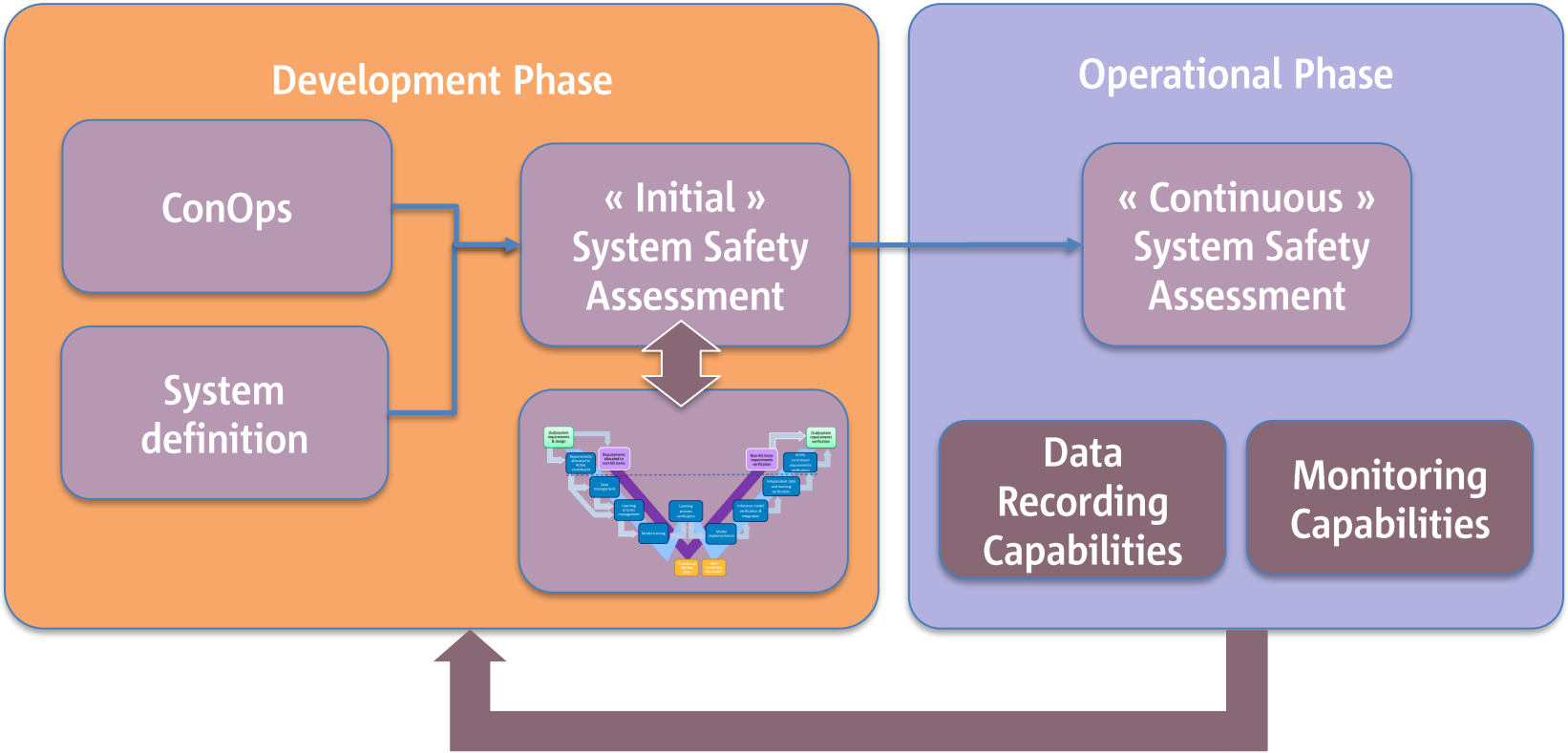
Honey-well use case

EASA

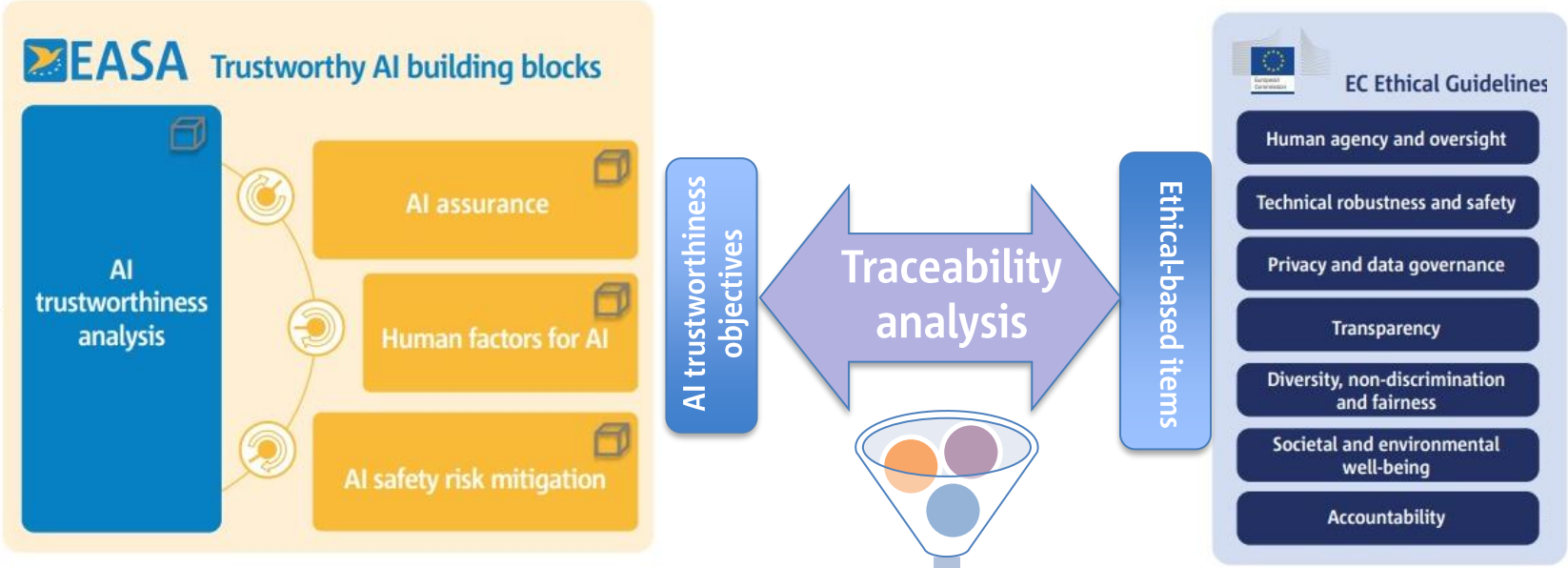
AI Assurance concept



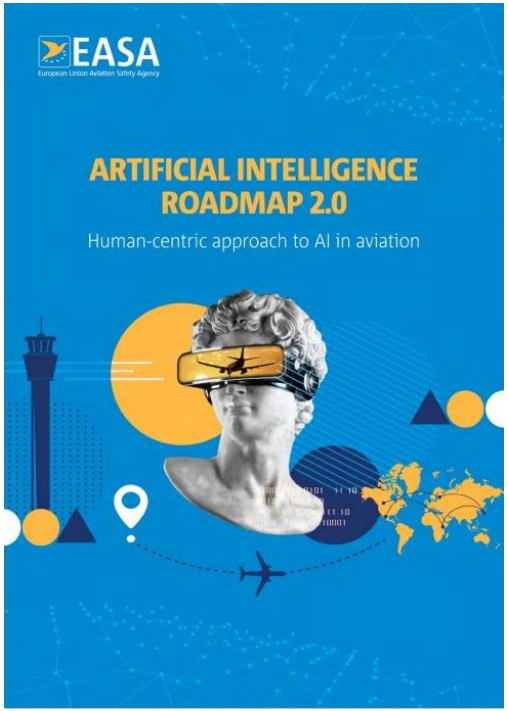
Continuous safety assessment concept



Ethics-based assessment concept



AI Roadmap 2.0 : Ariadne's thread



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Next AI Programme priorities

1
- Resolve public consultation comments and refine guidance
- Publish Concept Paper Issue 02 end of 2023
- Certify/approve first Level 1 AI applications

2
- Plan and execute the AI rulemaking concept
- Extend W-shaped process to reinforcement learning
- Extend technical guidance to knowledge-based and hybrid AI

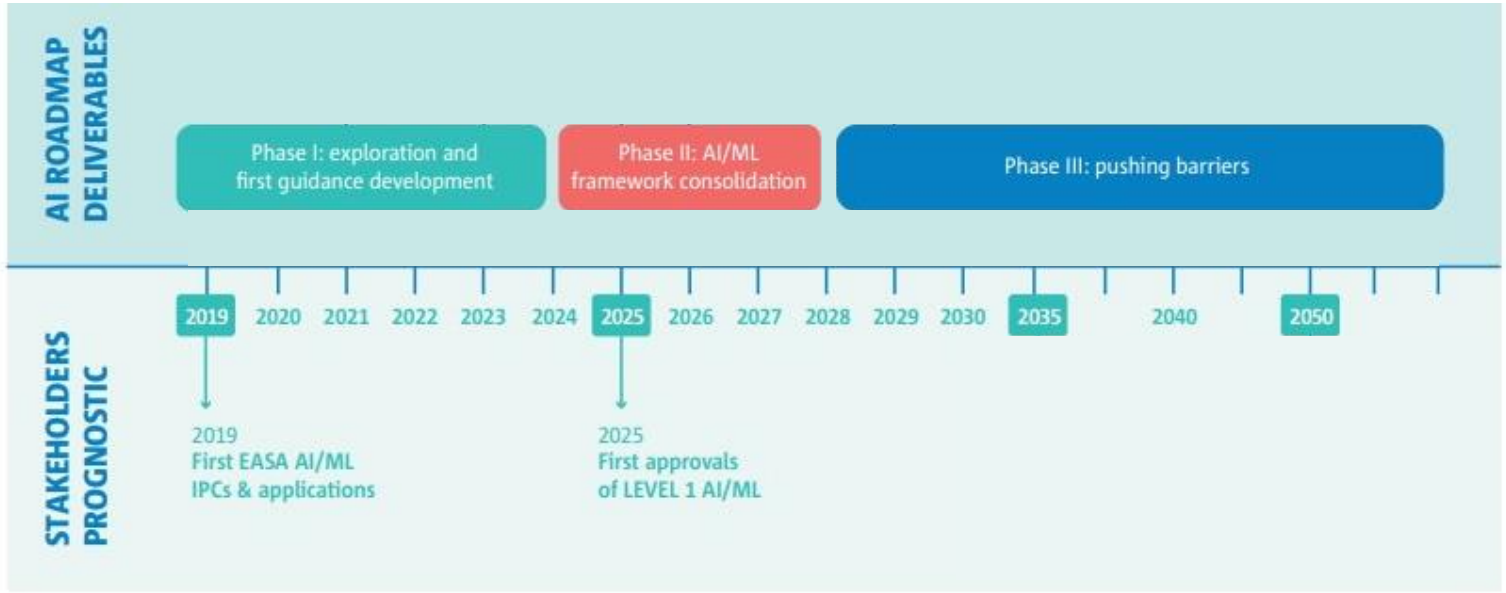
3
- Augment the AI Safety Risk Mitigation building block
- Anticipate necessary and feasible guidance for Level 3 AI

AI deployment timeline: Towards autonomous AI?

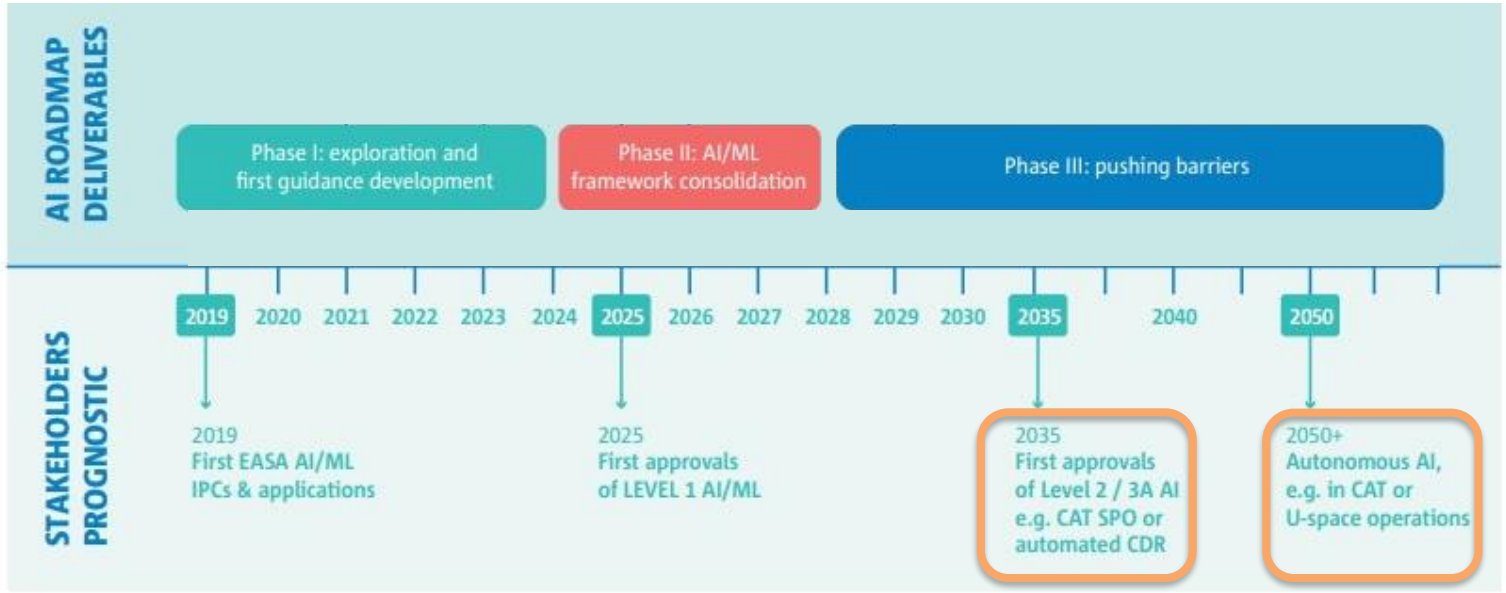
Alain Leroy – EASA Chief Engineer

EASA

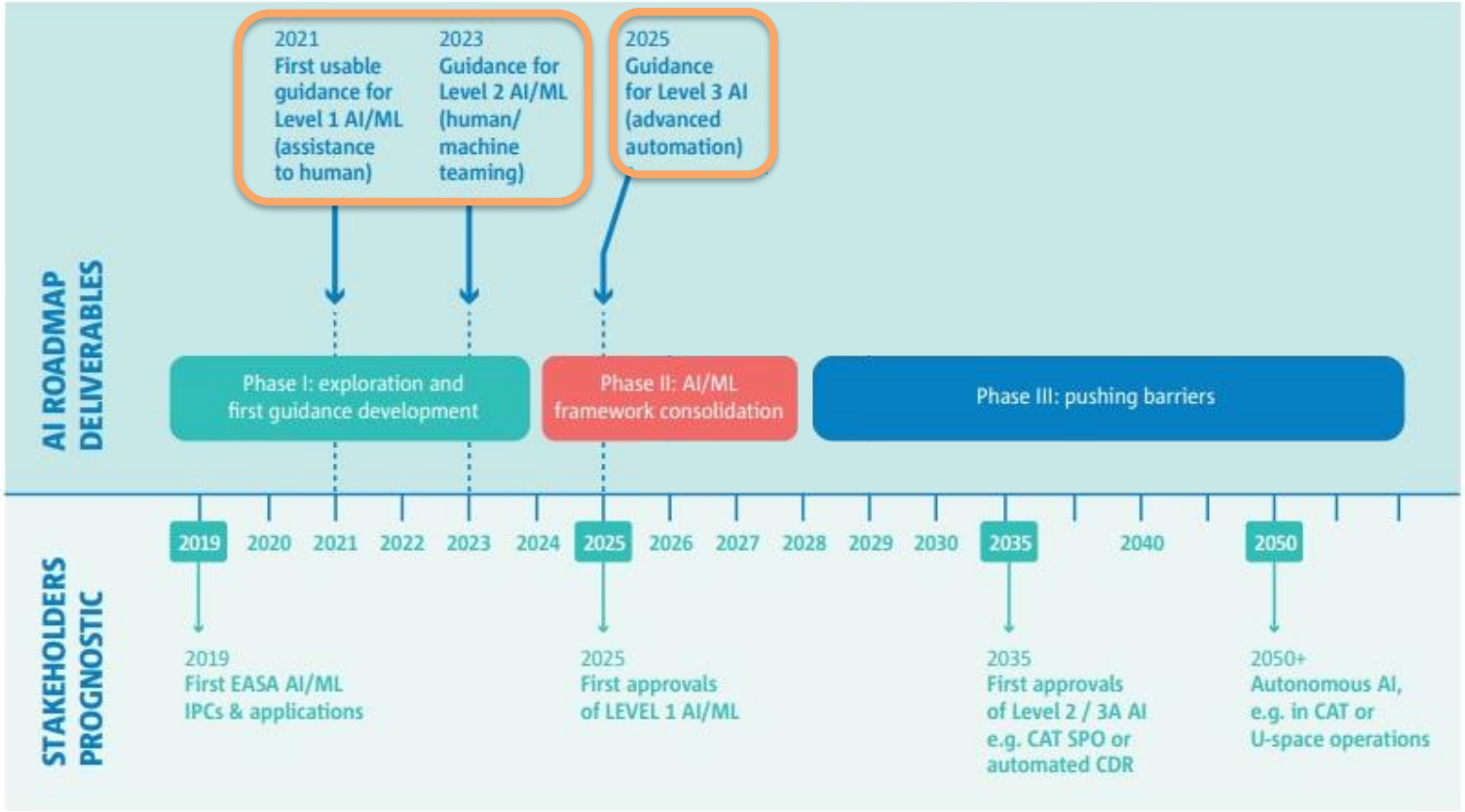
EASA AI Roadmap 2.0 : new timeline



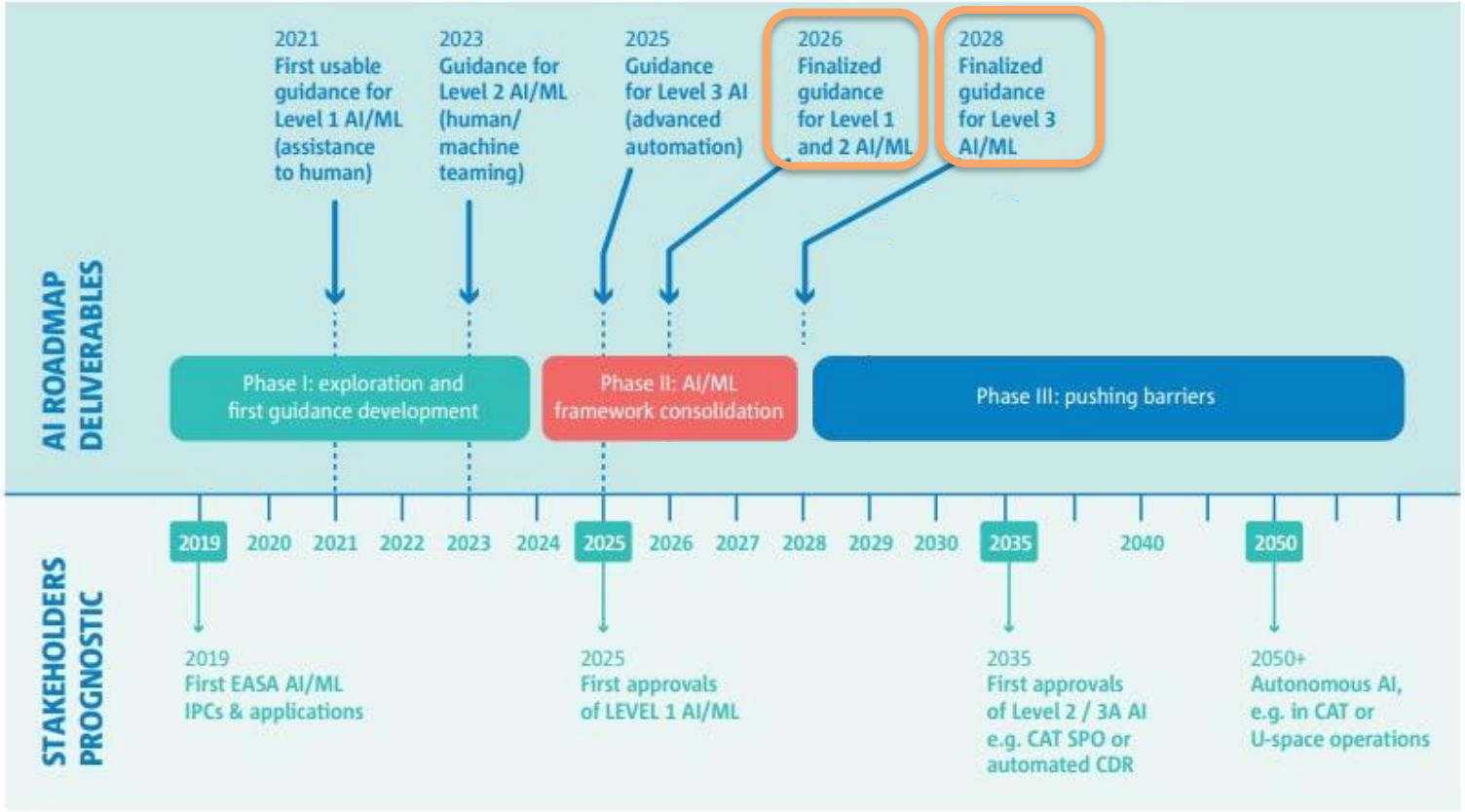
EASA AI Roadmap 2.0 : updated prognostic



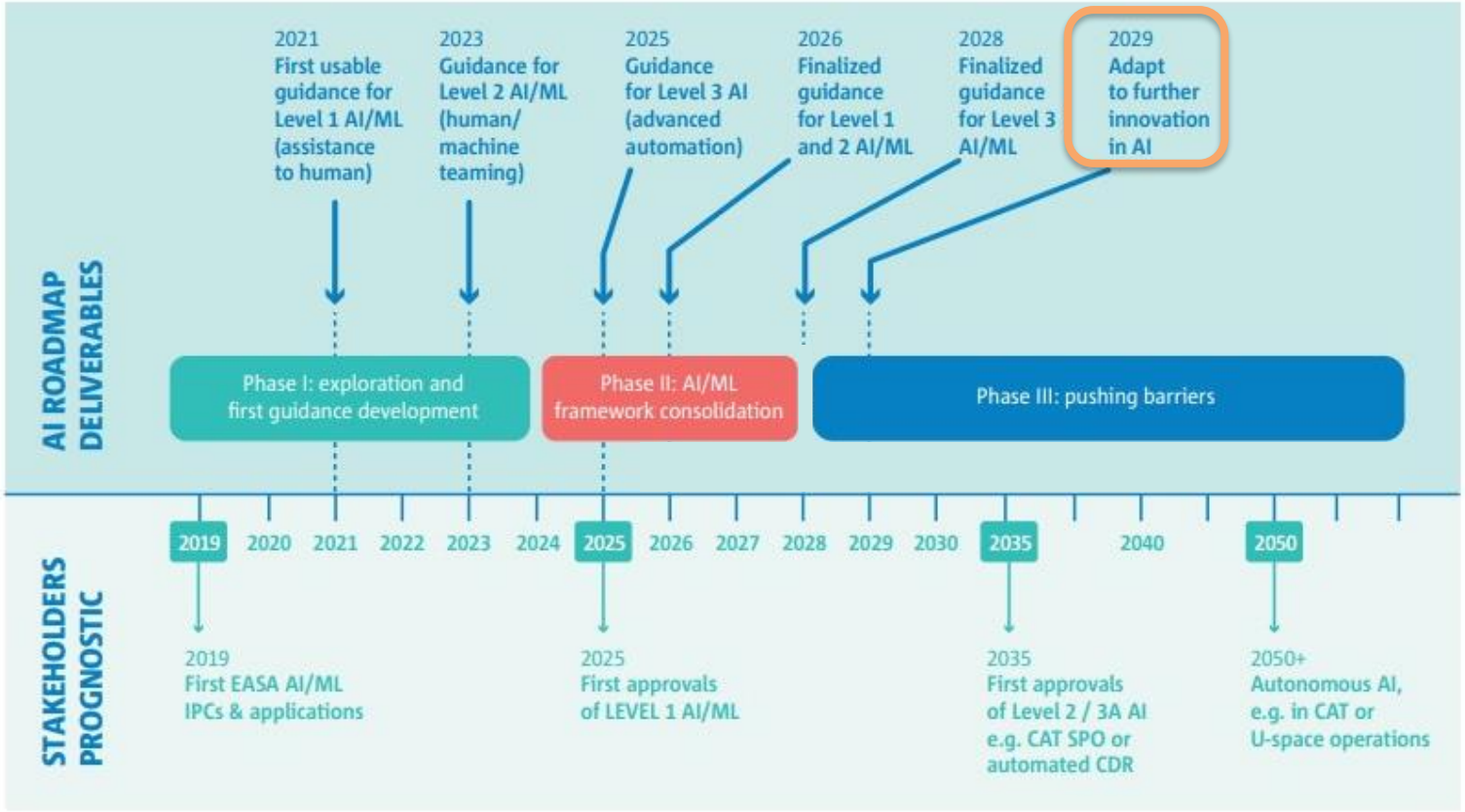
EASA AI Roadmap 2.0 : guidance delivery



EASA AI Roadmap 2.0 : consolidation phase



EASA AI Roadmap 2.0 : pushing barriers



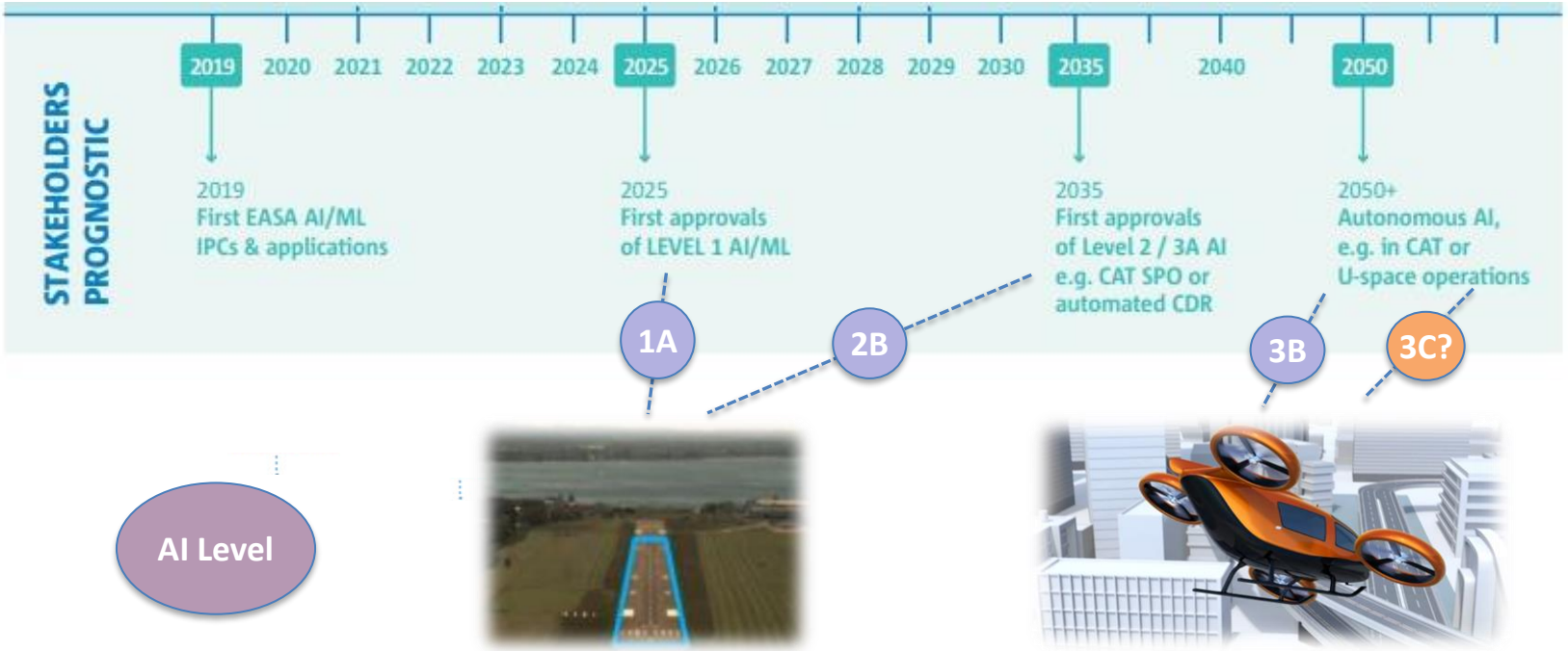
Top-level AI Roadmap 2.0 objectives

1. Develop a human-centric AI trustworthiness framework
2. Make EASA a leading oversight authority for AI
3. Support European aviation industry leadership in AI
4. Contribute to an efficient European AI research agenda
5. Contribute actively to EU AI strategies and initiatives

Engaging with all stakeholders

The top 5 objectives will be achieved:

What about autonomous operations?



AI use cases in aviation: Computer vision-based solutions

Dr. Luuk Van Dijk – CEO Daedalean

EASA

The Flightpath To Autonomy

Goes through OPV

Dr Luuk van Dijk Daedalean

We are Daedalean

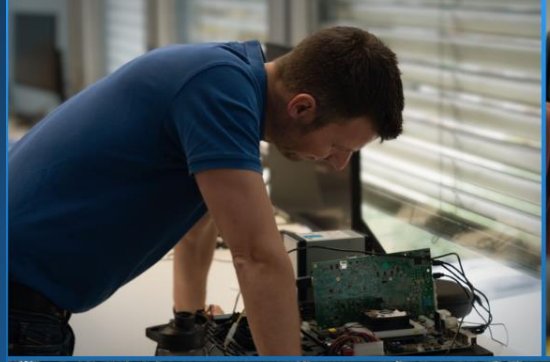
100+ staff

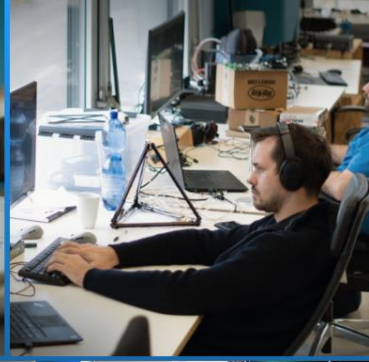
12 PhDs

11 pilots

Google
SpaceX
Airbus
intel
Pilatus
DLR German Aerospace Center
Rolls-Royce
Honeywell
CERN
kopter
BCG

Carnegie Mellon University
Imperial College London
University of Cambridge
University of Oxford
ETH zürich
Stanford University
Universiteit van Amsterdam
TU Delft Delft University of Technology








In 2016, we set out to build the world's first fully autonomous flight control system…

…making flying safer, scalable and smarter by replacing and outperforming the human pilot on every measurable dimension

Source: FAA-S-8081-16B

5 Plan

Plan the mission, modify the mission — pre-flight and en-route

4 Decide

Real-time decisions on board in normal and contingency situations

3 Communicate

Talk to air traffic controllers; understand other pilots

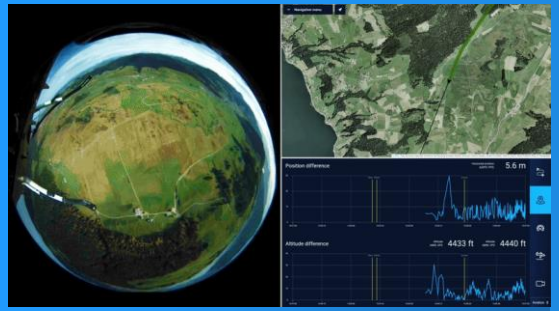
2 Navigate

Find optimal flight path, use existing air spaces, traffic patterns

1 Aviate

Perception; control; aircraft state monitoring. Always know where to land and avoid obstacles

VXS – Daedalean's Computer Vision suite to assist and to pilot in VMC



Where
am I?

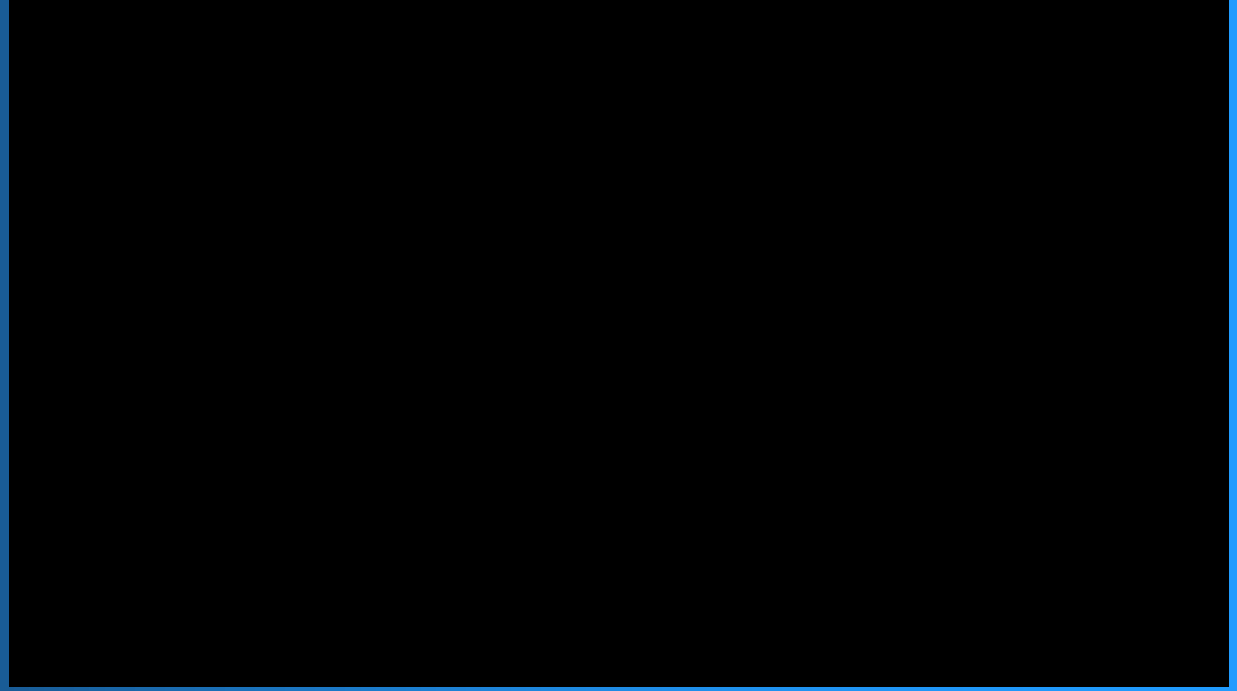
Where
can I fly?

Where
can I land?

Visual Traffic Detection

Detecting, tracking and providing information on all airborne objects with better accuracy than human pilots

(rotorcraft, fixed-wing, birds, drones…)



Functions

- Detects, classifies and tracks traffic, including non-cooperative
- Identifies size, position, direction of movement, time to collision

Properties

- Detection range up to 3 NM
- Independent of the ground infrastructure, based on avionics-grade high-resolution video cameras/IMUs
- Integration with existing flight deck instruments as a pilot-aid

Safety certification level

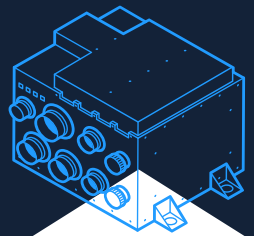
- DAL-C+

Underlying ~~magic~~ technology

Certifiable in-house machine-learned algorithms (neural networks)

System level

Cameras



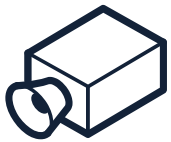
Aerospace-grade computing hardware

Updated path plan

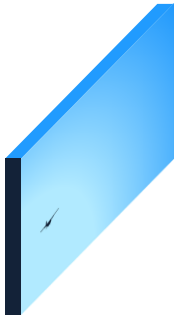
for the pilot or for the FCC

Control

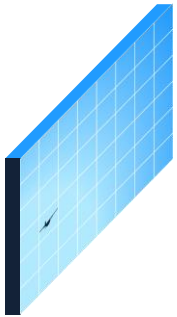
Software level

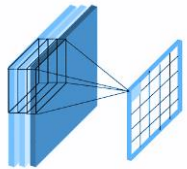


Camera



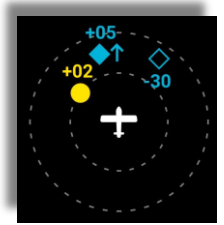
Preprocessing





Certifiable Convolutional Neural Network

Post-processing



Certification

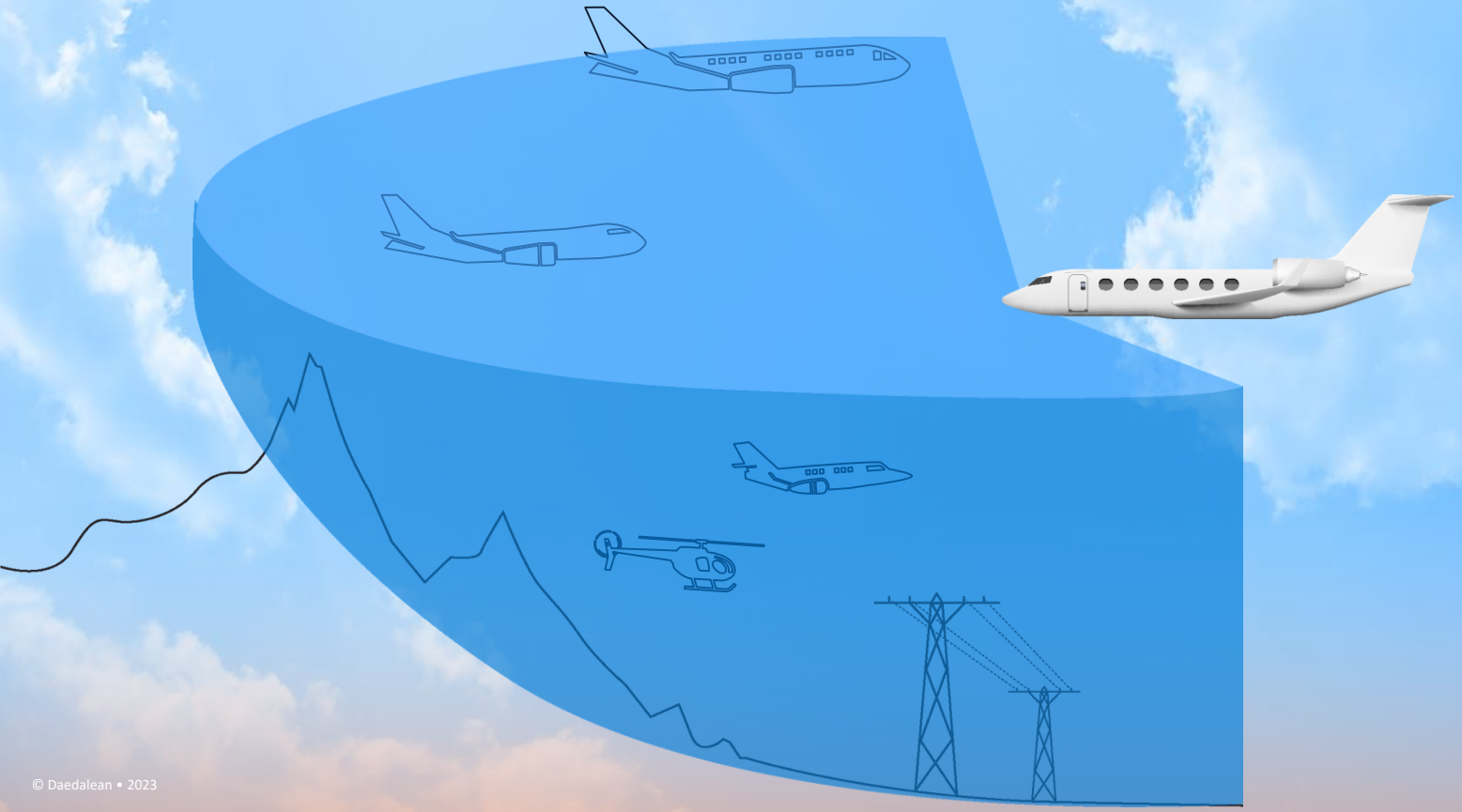
- DAL-C certification of Traffic Detection the first vision-based ML application
- Required creating new methodology for showing fitness for purpose and absence of unintended function

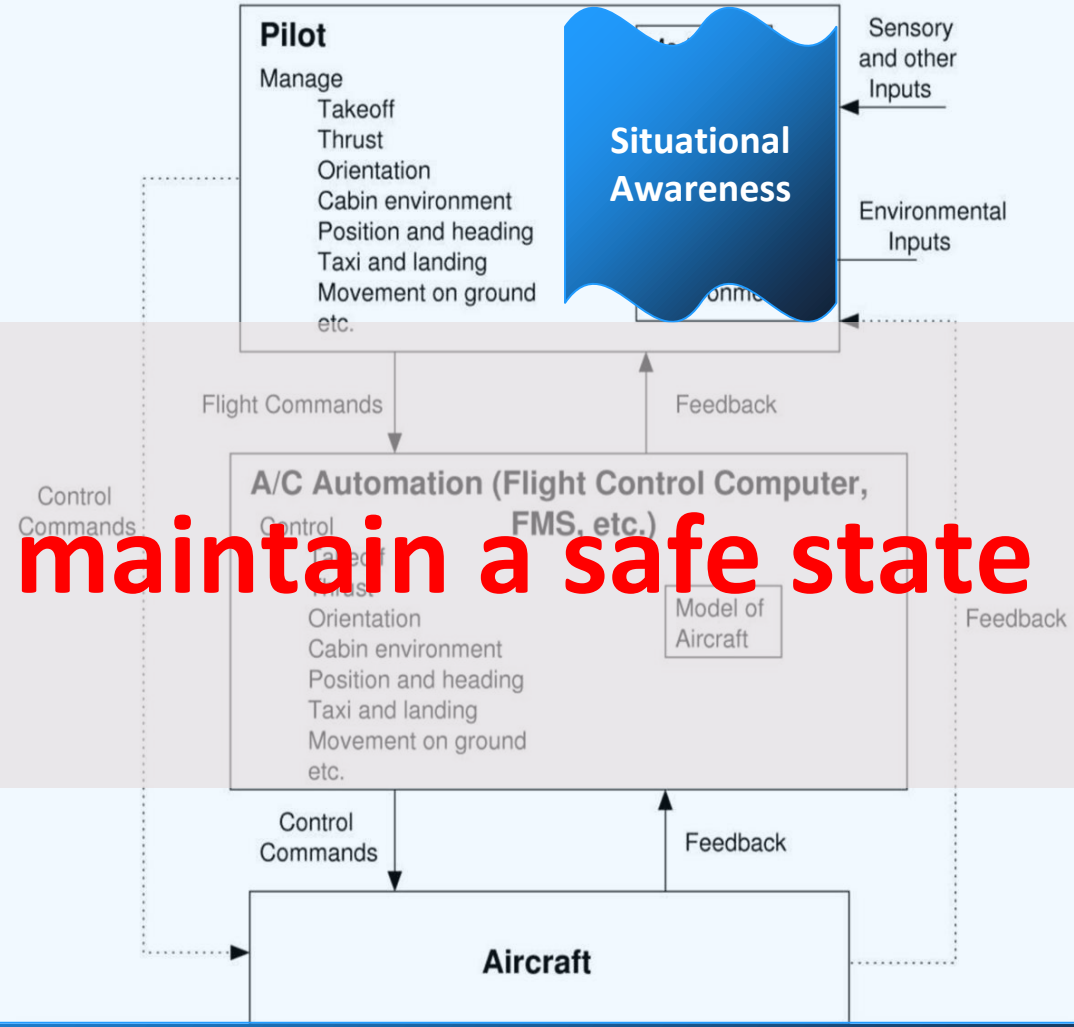
We are here
2023-05

1 → 2 → 3 → 4

1. A concept for Learning Assurance proposed, used by EASA in their “First usable guidance for Level 1 AI/ML application”
2. STC application for Traffic Detection
3. FAA issues Issue Paper, EASA issues a Certification Review Item
4. A specific application gets certified, referencings the NN policy among alternative means of compliance

What it is that a human pilot actually does?



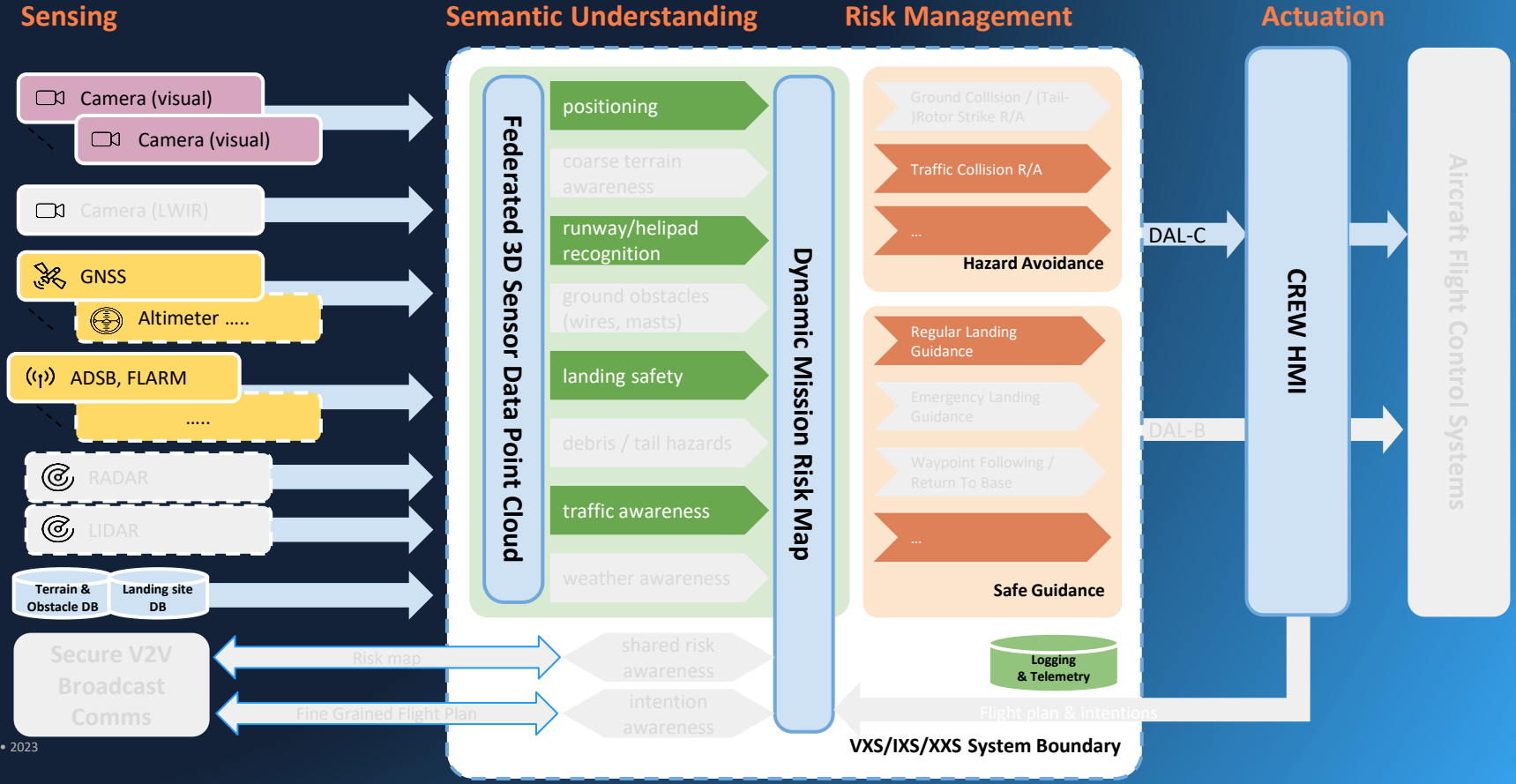


maintain a safe state

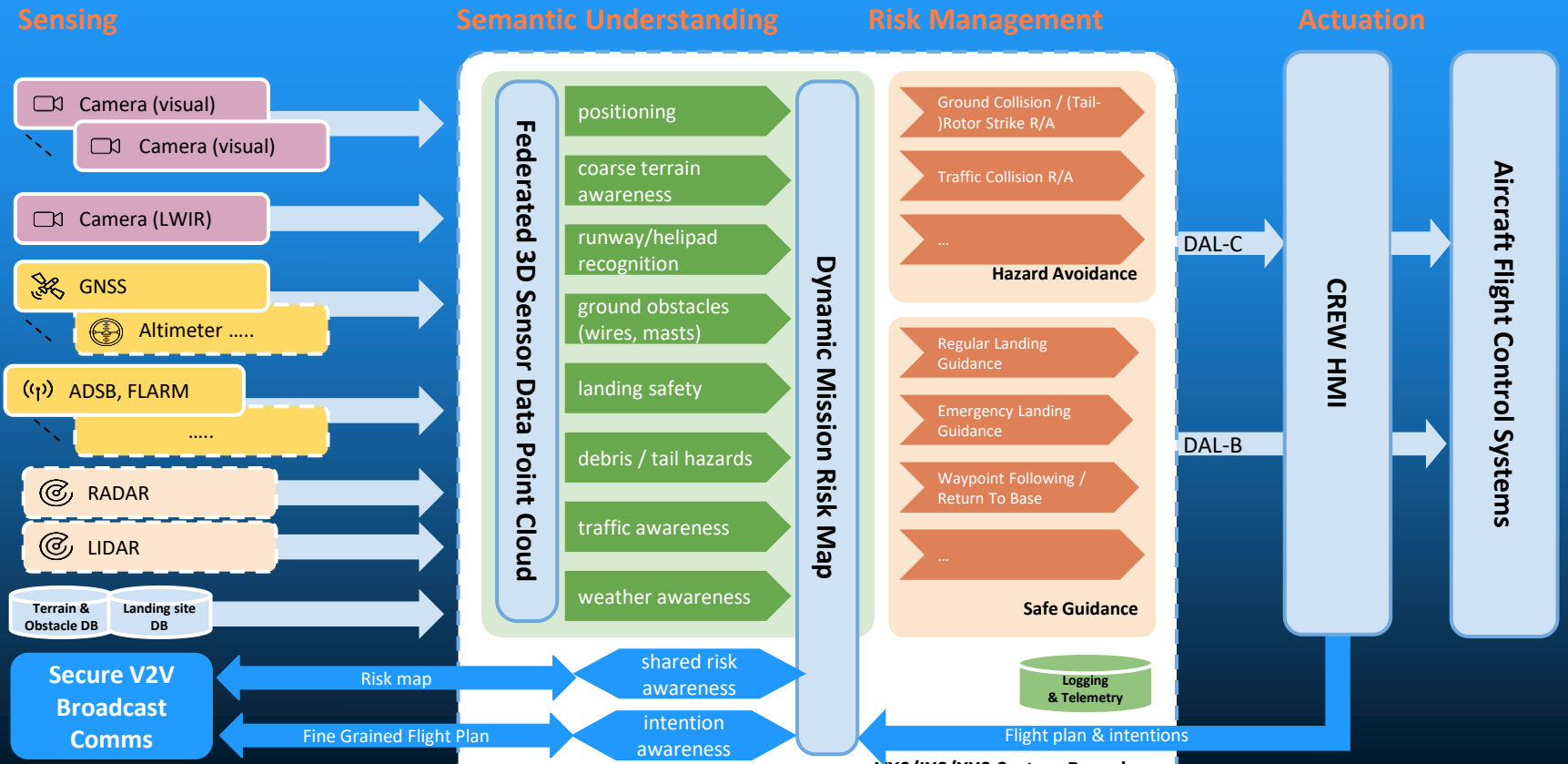
A Systems-Theoretic Approach to Safety in Software-Intensive Systems.

Nancy G. Leveson

Daedalean Situational Awareness Today



Daedalean Situational Awareness Tomorrow



Every single pilot gets a copilot

- Create the aircraft that doesn’t kill anyone if you take your hands off the controls
- Make pilot interface with the flight plan, not with the aircraft

AI use cases in aviation:
Air Traffic Management assistance

Assoc. Pr. Sameer Alam – Deputy Director ATMRI Singapore

EASA

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Some Use Cases of Artificial Intelligence in Air Traffic Management

EASA AI Days
16th & 17th May 2023
Cologne, Germany

Associate Professor Sameer Alam PhD
Deputy Director, Air Traffic Management Research Institute
School of Mechanical & Aerospace Engineering

Agenda

I. ATMRI Introduction
II. Use Case of AI in ATM for Airport Airside
III. Use Case of AI in ATM for Digital Towers
IV. Use Case of AI in ATM for Terminal Airspace
V. Use Case of AI in ATM for En-Route Airsapce

Air Traffic Management Research Institute (ATMRI)
NTU Singapore

- Established in 2013 as CAAS-NTU joint-research and experimental centre.
- 5 Faculty, 31 research staff and 18 PhD students.

Artificial Intelligence and Data Analytics for ATM

Research Aim: To develop a suite of intelligent algorithms that can learn, generalize and predict from ATCO actions and air traffic data to assist ATCOs perform higher-order cognitive tasks with transparency, explainability and trust.

Hybrid AI-Human ATM System

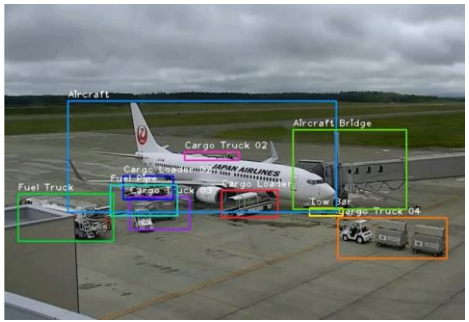
Use Case – Airside

Visual Detection, Tracking and Prediction of Airfield Objects

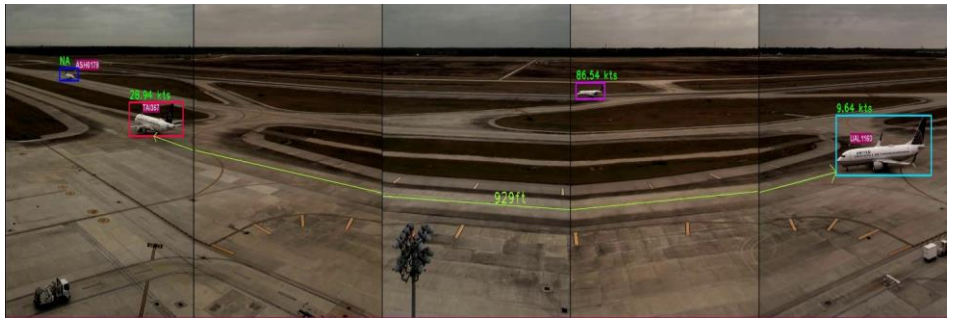
Computer Vision & Deep Learning to Detect and Track Aircraft, Drones & Vehicle

Airports are complex, congested, safety-critical environments featuring a variety of cooperative and non-cooperative small flying objects.

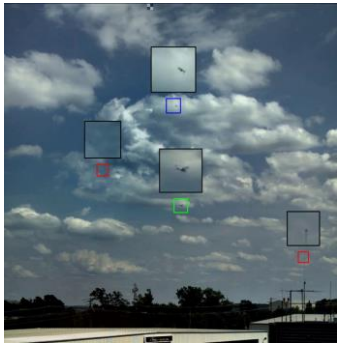
Push Back Prediction



Airport- Airside Surveillance

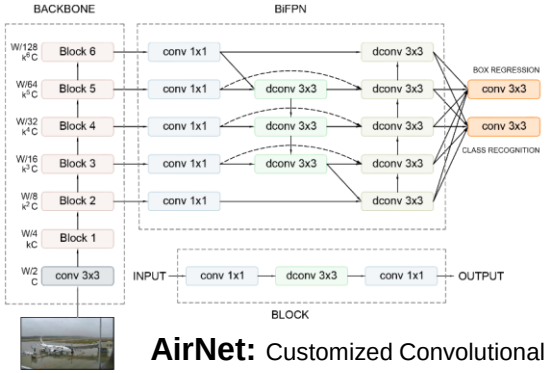


Bird & Drone Detection



Airport- Airside Surveillance

- Calibrate cameras
- Detect and track aircraft
- Transform pixel location to geographic location
- Assign aircraft to corresponding regions (runway/taxiways)
- Estimate speed and distance by the haversine formula

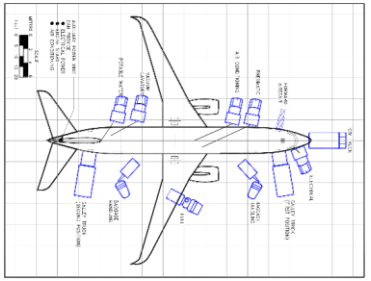


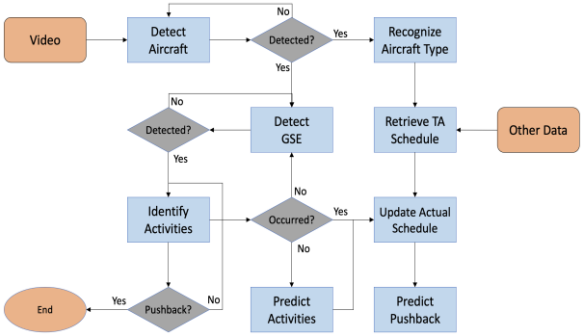
AirNet: Customized Convolutional Neural Network

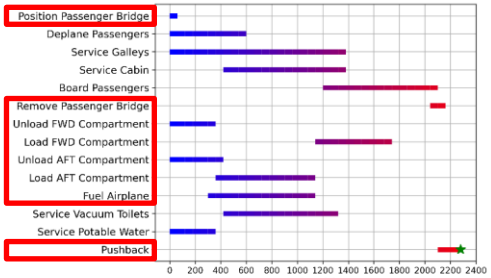
Van Phat, T., Alam, S., Lilith, N., Tran, P. N., & Binh, N. T. (2021). Deep4air: A novel deep learning framework for airport airside surveillance. In 2021 IEEE International Conference on Multimedia & Expo Workshops (ICME)

Turnaround Monitoring

- Detect aircraft and GSE
- Identify occurred activities
- Predict future activities
- Predict pushback



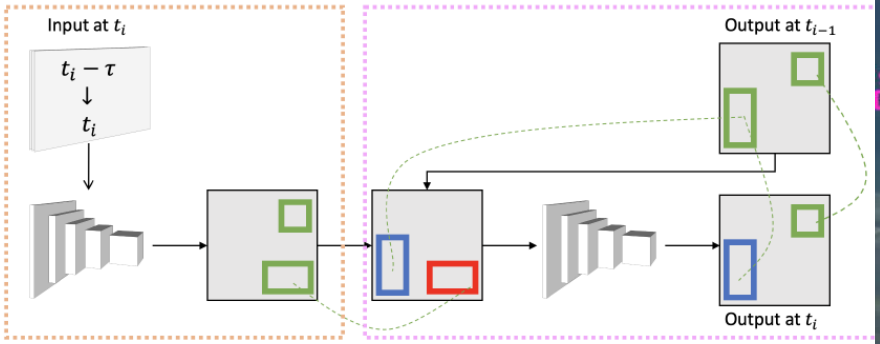




Thai, P., Alam, S., Lilith, N., & Nguyen, B. T. (2022). A computer vision framework using Convolutional Neural Networks for airport-airside surveillance. Transportation Research Part C: Emerging Technologies, 137, 103590

Small Flying Object Detection

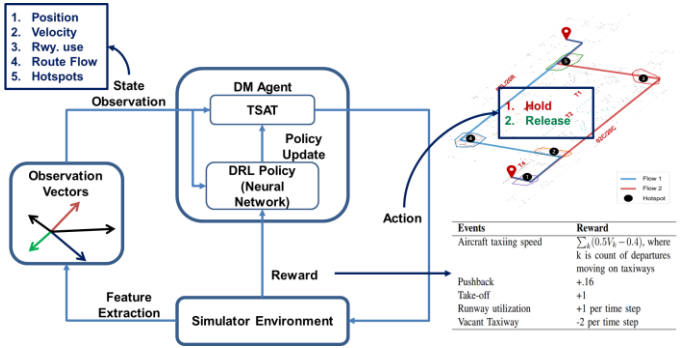
- Leesburg digital tower (aircraft) and self-record (drone)
- 28 FHD videos with an average duration of 20 seconds
- Average object size is 15 pixels
- Extract frames and manually label objects as bounding boxes
- Augment data by deep learning algorithm

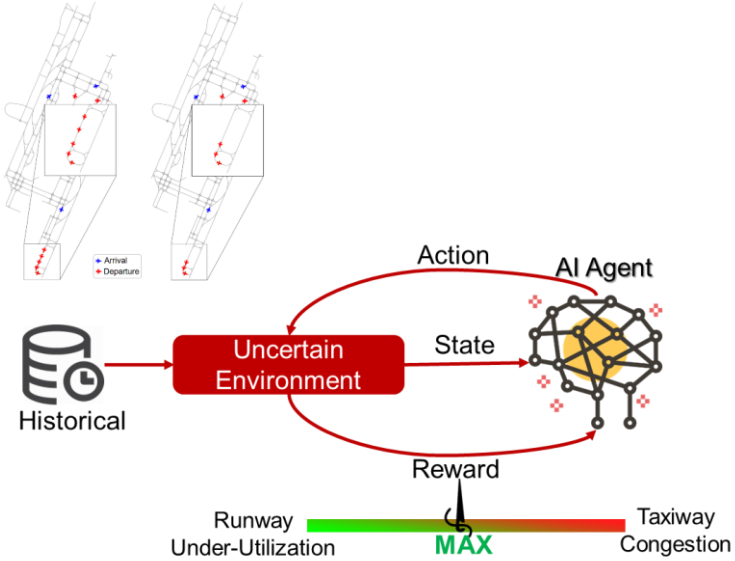


Thai, V.P., Zhong, W., Pham, D.T., Alam, S. and Duong, V. N. (2019). Detection, Tracking and Classification of Aircraft and Drones in Digital Towers Using Machine Learning on Motion Patterns, ICNS 2019, USA

Use Case – Airside

Intelligent Departure Metering





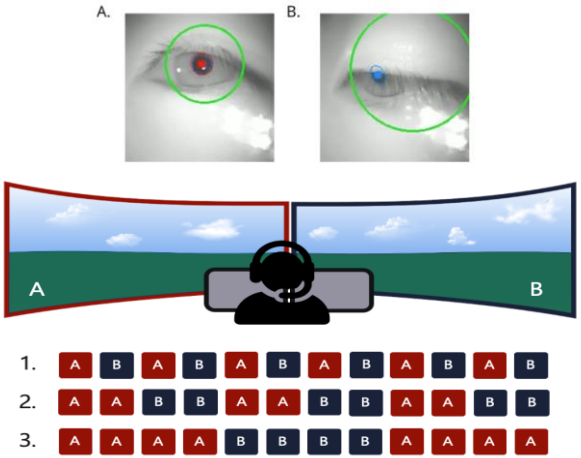
Hasnain Ali, Duc-Thinh Pham, Michael Schultz, and Sameer Alam (2022). *A Deep Reinforcement Learning Approach for Airport Departure Metering under Spatial-Temporal Airside Interactions.* IEEE Transactions on Intelligent Transportation Systems

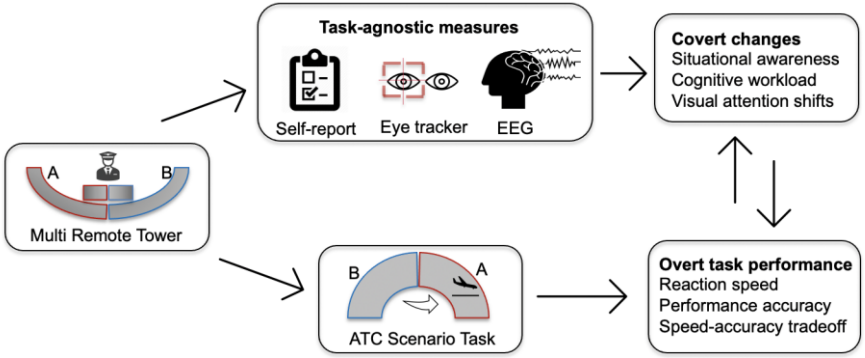
Use Case – Digital Towers

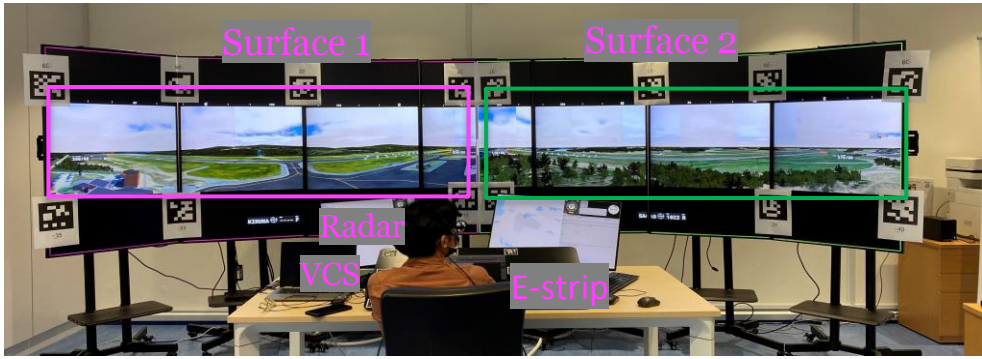
ATC Mental Model in Digital Tower Scenario

Neuro-Cognitive Modelling and Assessment of Intelligent Tools in a Multi-Remote Tower Environment:

- Attention Switching impact on Workload in Multi Remote Tower Operation





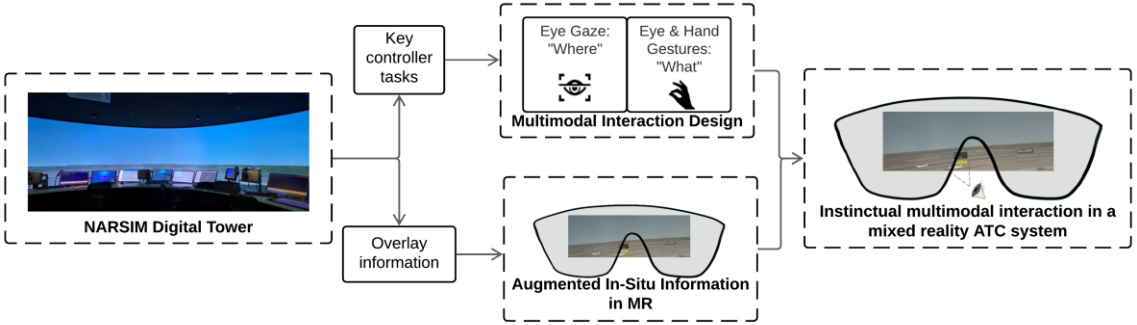


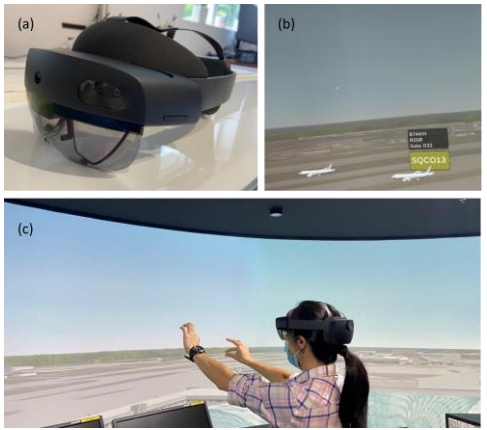
Lu, Z., Alam, S., Lilith, N., and Josefsson, B. The Impact of Mental Model Switching on Air Traffic Controller's Workload in Multi Remote Tower Operations, 10th Intl. Conference on Research in Air Transportation (ICRAT 2022), Florida, USA

Use Case – Digital Towers

Portable Air Traffic Digital Tower through an Interactive Mixed Reality System

- To developed a portable air traffic digital tower in Microsoft HoloLens 2, spatially mapped within a 360-degree tower simulator.



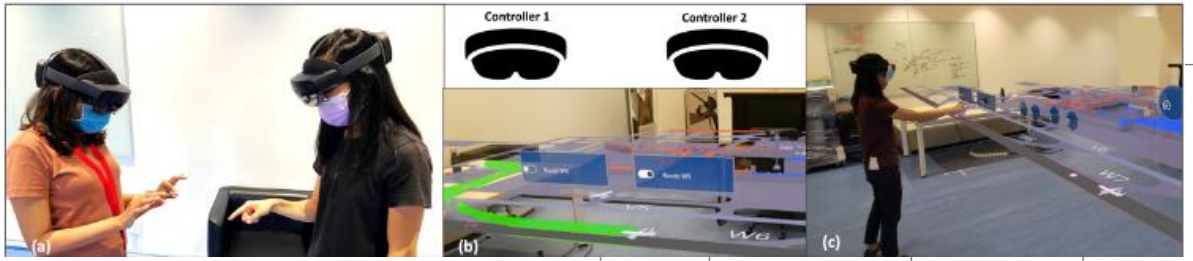


- Conducted a user evaluation to validate system usefulness across visibility conditions with licensed ATCOs
- Validated the final system with a formal system evaluation comprising a human-in-the-loop experiment that demonstrates its usability in an operational environment.

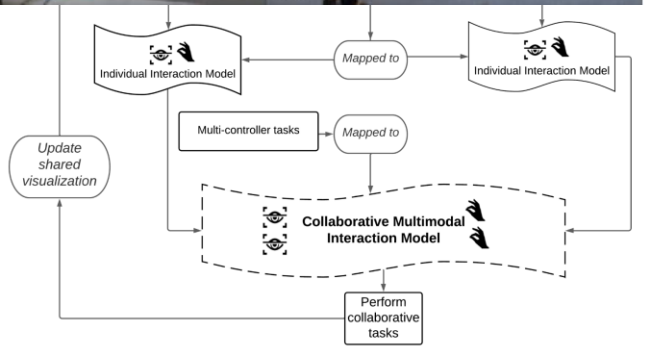
Mohan, P., Alam, S., Nadirsha, T. M., Lilith, N., & Svensson, A. (2021). Embodied Multimodal Interaction with a Portable Mixed Reality-based Digital Tower., 14th USA/Europe ATM R&D Seminar, Online/New Orleans. USA.

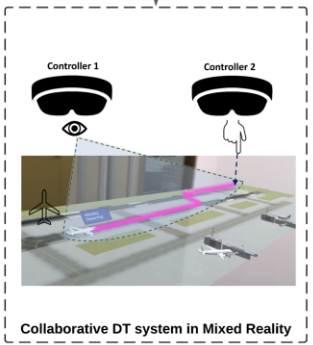
Use Case – Digital Towers

An Interactive Mixed Reality-based Approach for Collaborative Digital Tower Operations



- Provides a shared visual understanding of the situation to multiple ATCOs wearing HoloLens 2.
- Functionalities : Collaborative routing, Collaborative sequencing

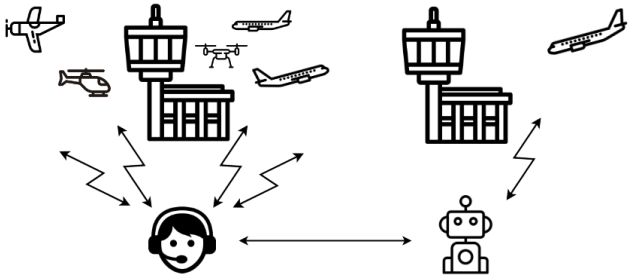




Mohan, Pallavi, Sameer Alam, TN Mohammed Nadirsha, Nimrod Lilith, and Åsa Svensson. "A Shared Interactive Space in Mixed Reality for Collaborative Digital Tower Operations." In *2022 IEEE International Symposium on Mixed and Augmented Reality,* pp. 615-621. IEEE, 2022.

Use Case – Digital Towers

Digital Tower Assistant
For Multiple Remote Tower

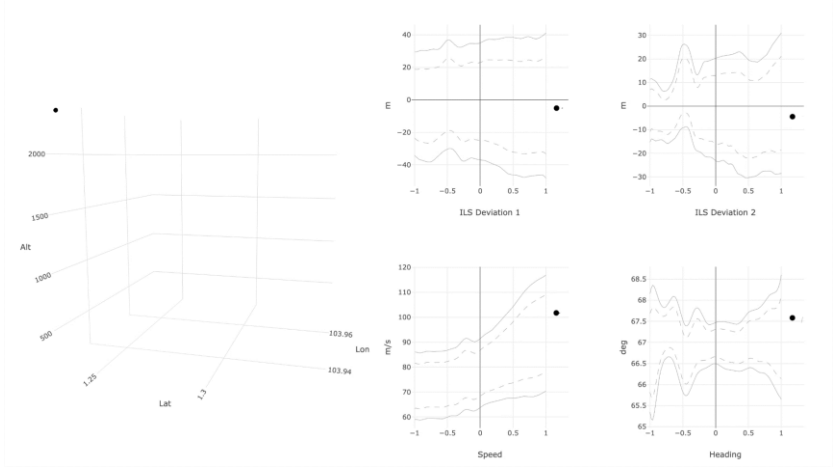


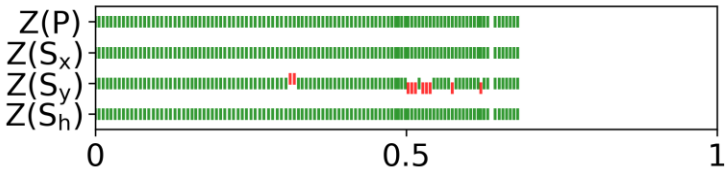
The ATCO manages traffic at a high-intensity traffic airport and delegates the Digital Assistant (DiTA) to simultaneously manage traffic at a low-intensity traffic airport.

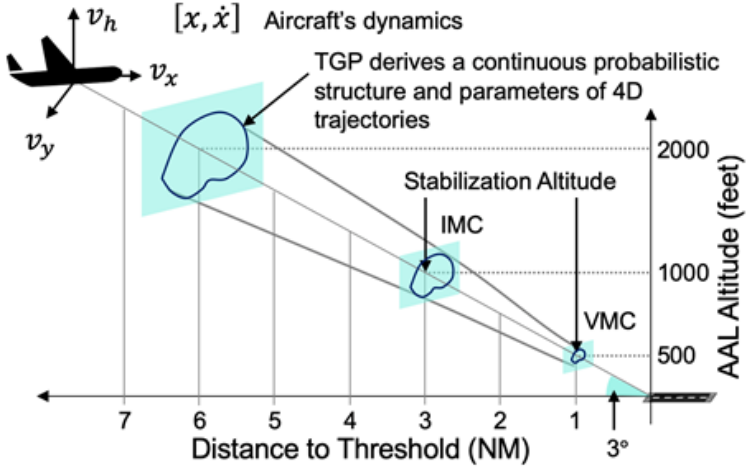
Jonas et.al., Digital ATCO Assistant (DITA) For Multiple Remote Tower - Virtual Reality Demonstration and Concept, SESAR Innovation Days 2022, Budapest, Hungary.

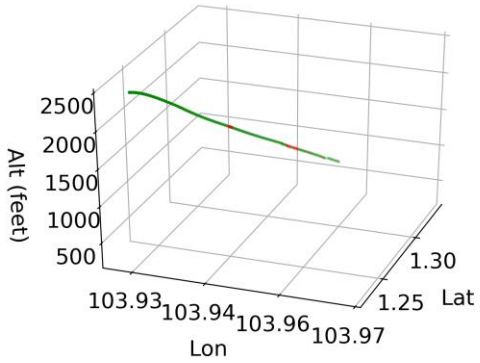
Use Case: TMA

Unstable Approach Detection







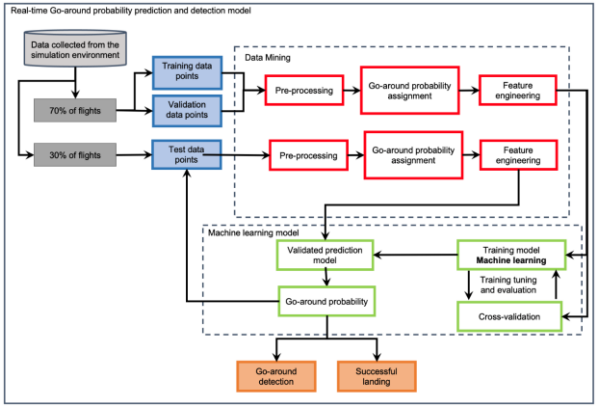


Goh, Sim Kuan, Narendra Pratap Singh, Zhi Jun Lim, and Sameer Alam. "Interpretable Tracking and Detection of Unstable Approaches Using Tunnel Gaussian Process." IEEE Transactions on Aerospace and Electronic Systems (2022).

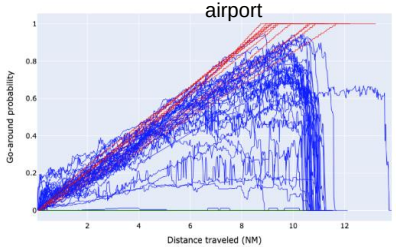
Use Case: TMA

A real-time go-around probability prediction model

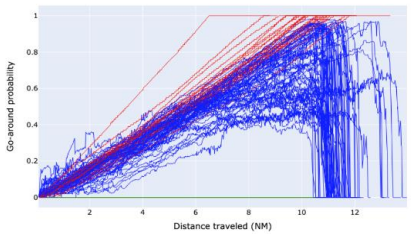
- Go-around is a safety critical maneuver.
- Last-minute instructions given by ATCs overload pilots.
- Go-around maneuver increases the cognitive workload on controllers.

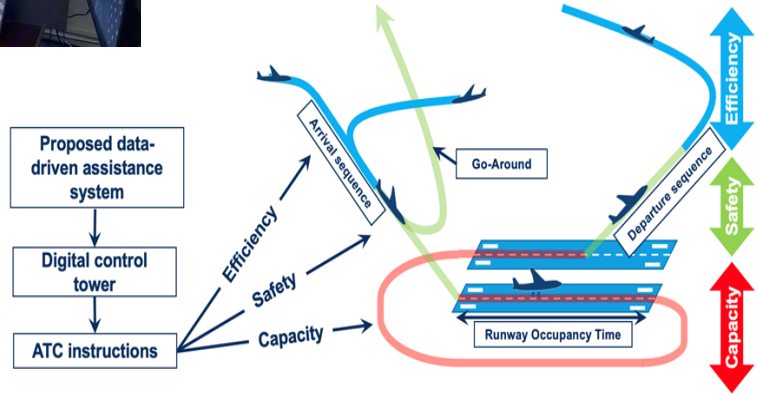


KVNY airport



KPHL airport



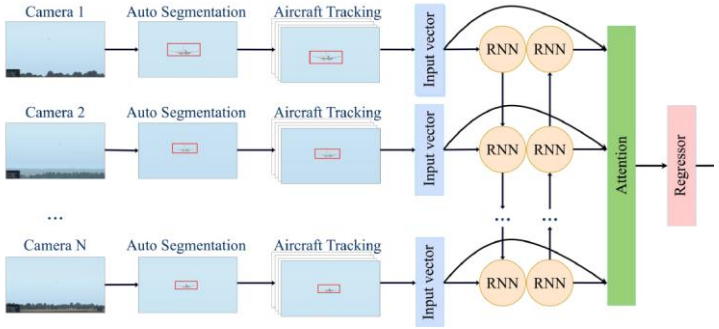


Dhief, Imen, Sameer Alam, Nimrod Lilith, and Chan Chea Mean. "A machine learned go-around prediction model using pilot-in-the-loop simulations." *Transportation Research Part C: Emerging Technologies* 140 (2022): 103704.

Use Case: TMA

Distance to Touch Down Prediction

A multi-view vision-based deep learning approach for Distance-to-touchdown prediction.

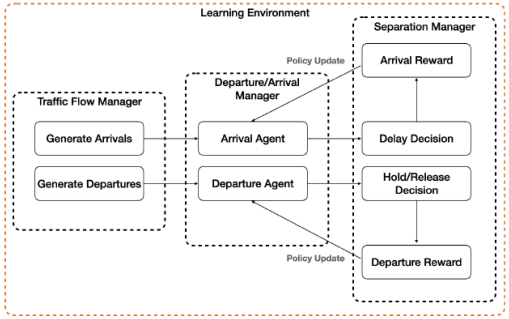


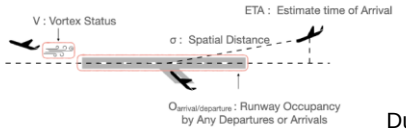
Gabriel James, Duc-Thinh Pham, Sameer Alam . A Multi-Camera Depth Learning Approach for Distance-from-Touchdown Estimation of Approaching Aircraft, SESAR Innovation Days 2022, Budapest, Hungary.

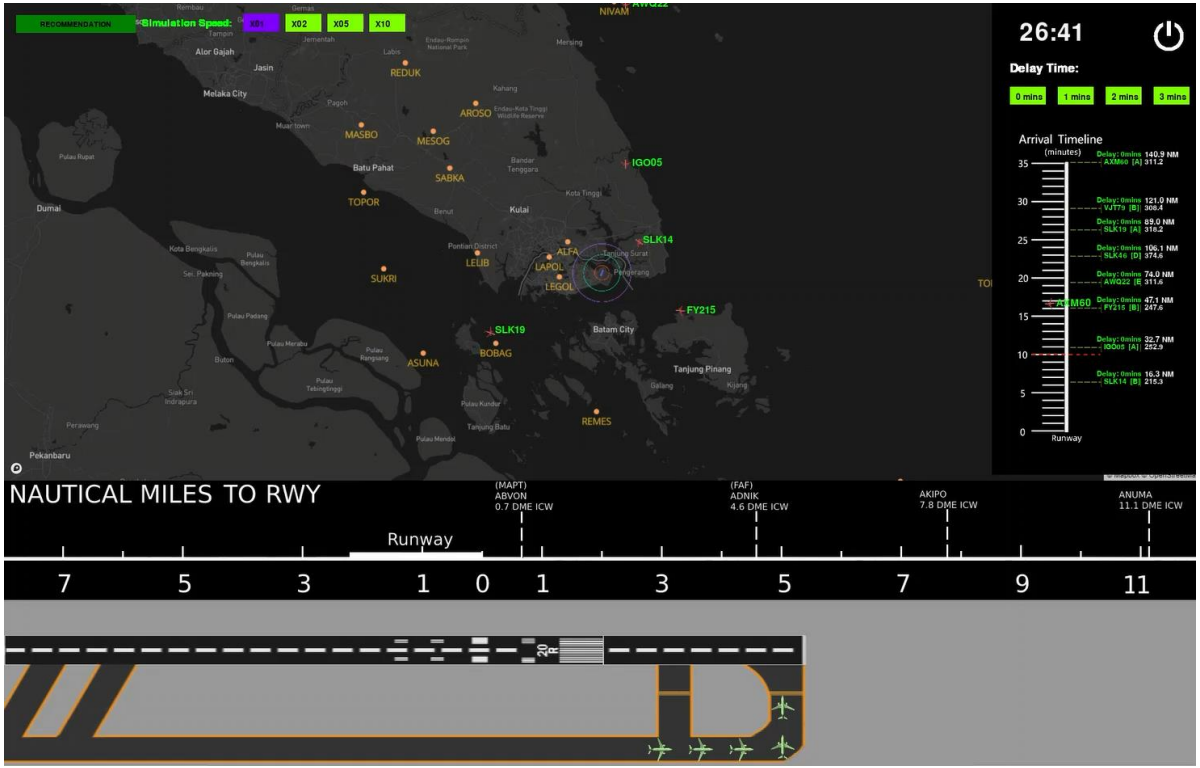
Use Case: TMA

Mixed-Mode Runway Sequencing

- Multi-agent Deep Reinforcement Learning approach using Multi-agent Deep Deterministic Policy Gradient to train two agents simultaneously: departure agent, and arrival agent.
- The departure agent makes departure slotting decisions for departures while the arrival agent determines the time delay or spacing decision on the arrival stream.



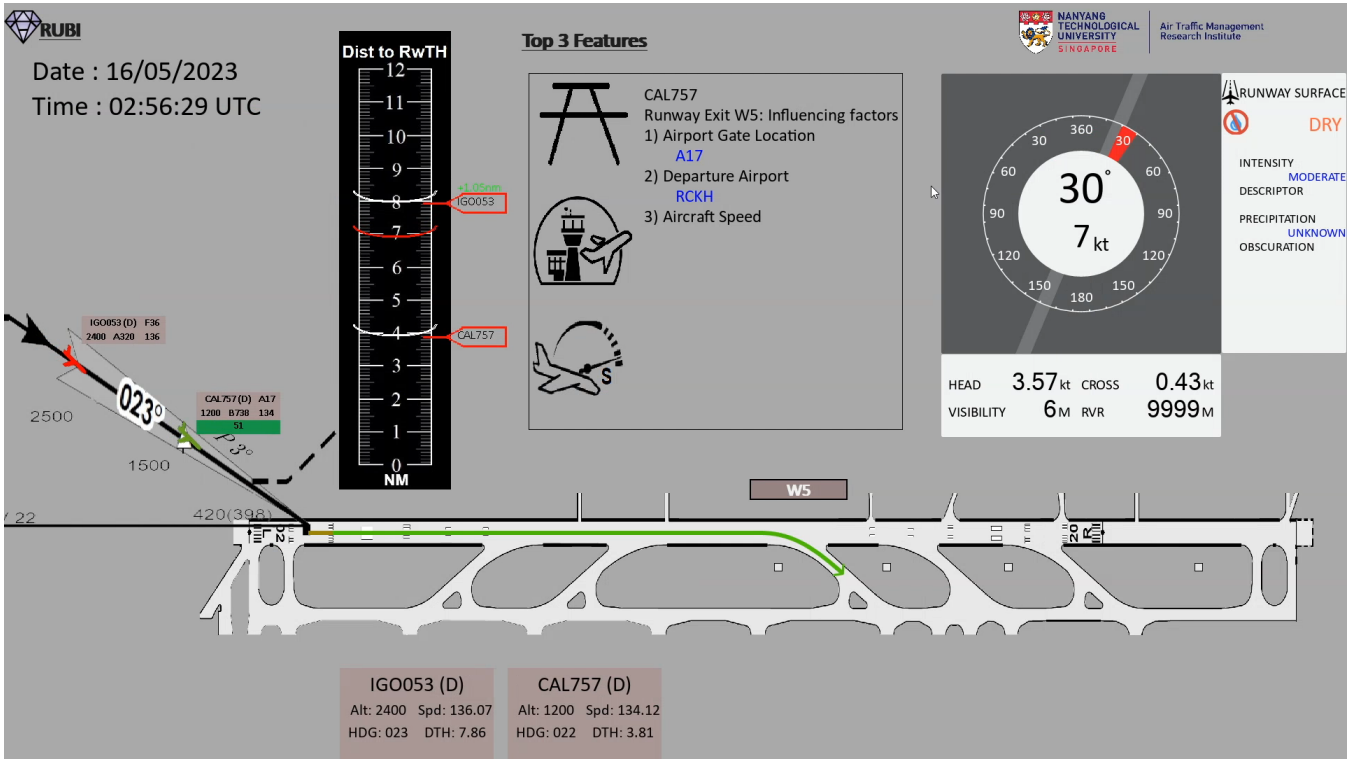




Duc-Thinh Pham, LiLong Chan, Sameer Alam, and Rainer Koelle (2021). “Real-time departure slotting in mixed-mode operations using deep reinforcement learning : a case study of Zurich airport.” *14th US & Europe Air Traffic Management Research and Development Seminar 2021*

Use Case: TMA

Runway Exit Prediction and Spacing Advisor

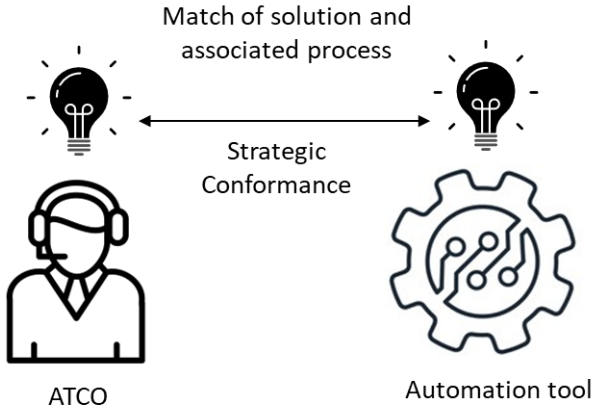


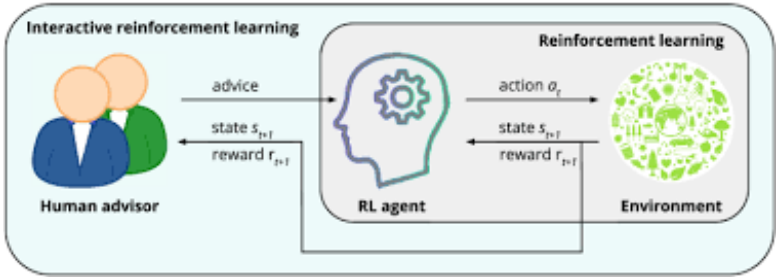
Woo, Chuan Jie, Sim Kuan Goh, Sameer Alam, Md Meftahul Ferdaus, and Mohamed Ellejmi. "A runway exit prediction model with visually explainable machine decisions." (2022), ICRAT, USA.

Use Case: Enroute Airspace

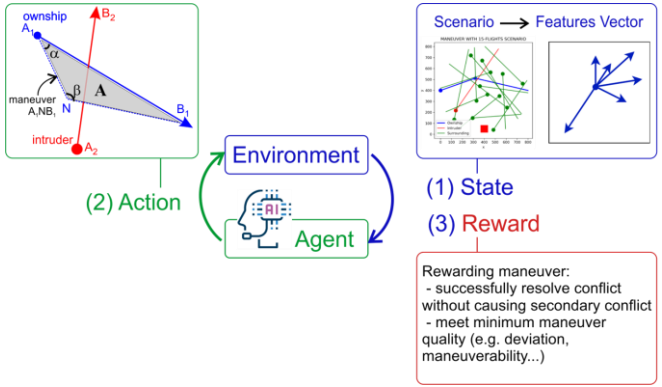
Air Traffic Conflict Resolution

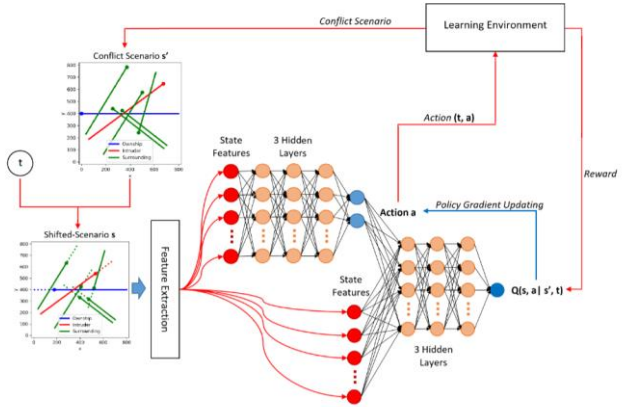
- Lack of Conformance in Conflict Resolution Tools.
- Degree to which automation's problem-solving style matches that of the individual human.
- Two components: Conformance in terms of the solution (the product) and conformance in terms of the associated process(underlying strategy).

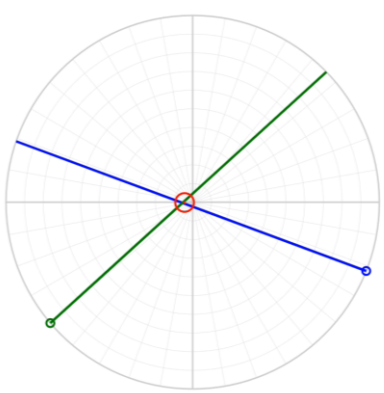




Air Traffic Conflict Resolution : Self Learning

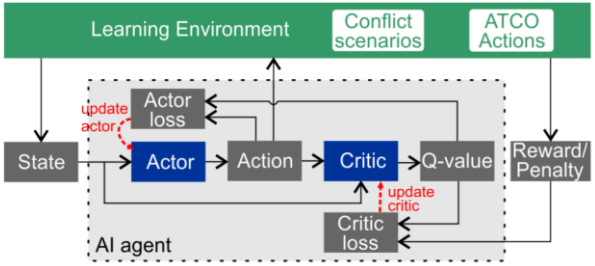


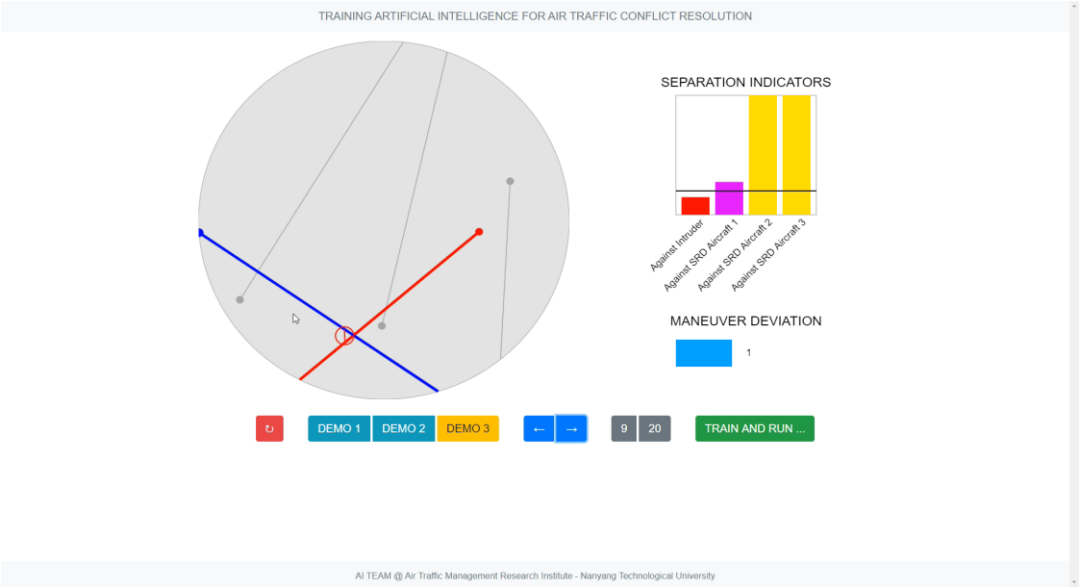


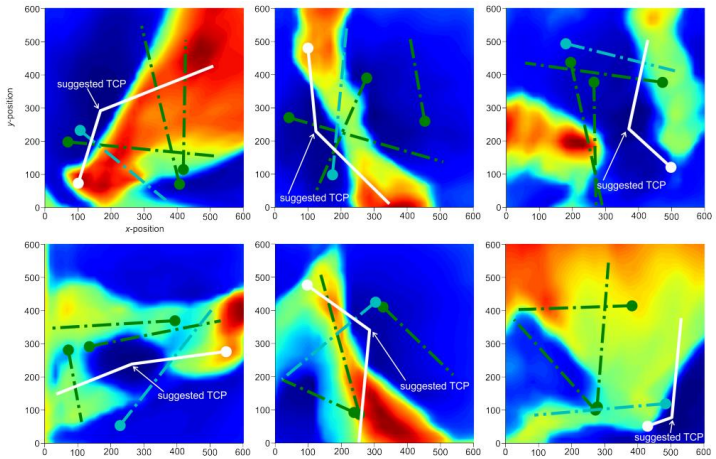


Pham, D., Tran, P. N., Alam, S., Duong, V. & Delahaye, D. (2022). Deep reinforcement learning based path stretch vector resolution in dense traffic with uncertainties. Transportation Research Part C: Emerging Technologies, 135, 103463.

Air Traffic Conflict Resolution : Human Advised Learning - Abstract

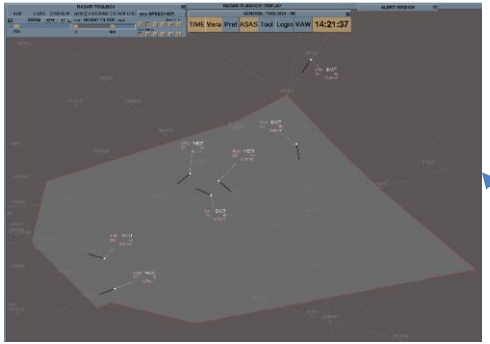


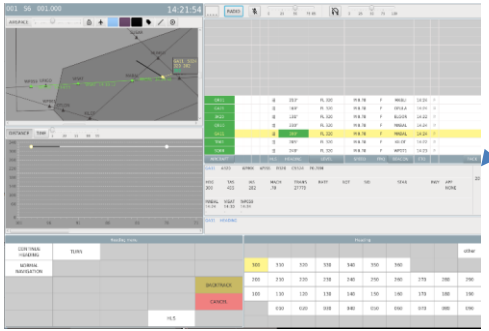


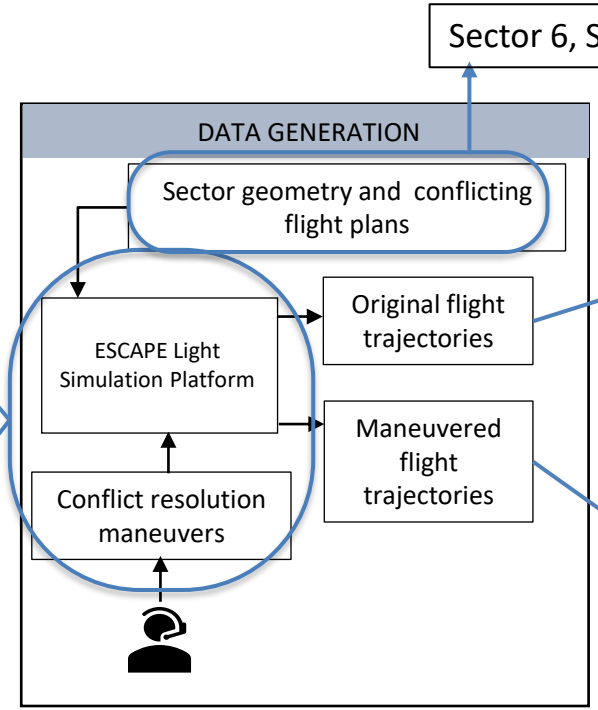


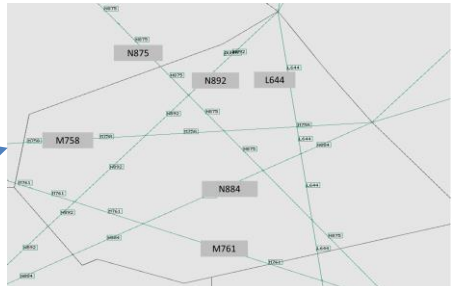
Tran, P. N., Pham, D. T., Goh, S. K., Alam, S., and Duong, V. (2020). An Interactive Conflict Solver for Learning Air Traffic Conflict Resolutions. Journal of Aerospace Information Systems, 17(6), 271-277

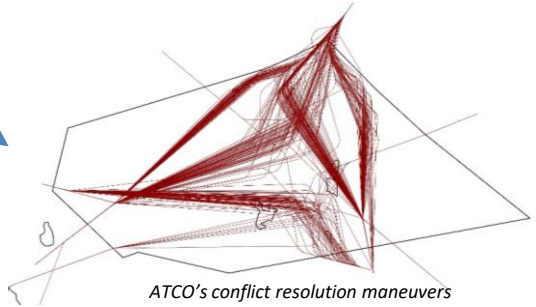
Air Traffic Conflict Resolution : Human Advised Learning - Simulation









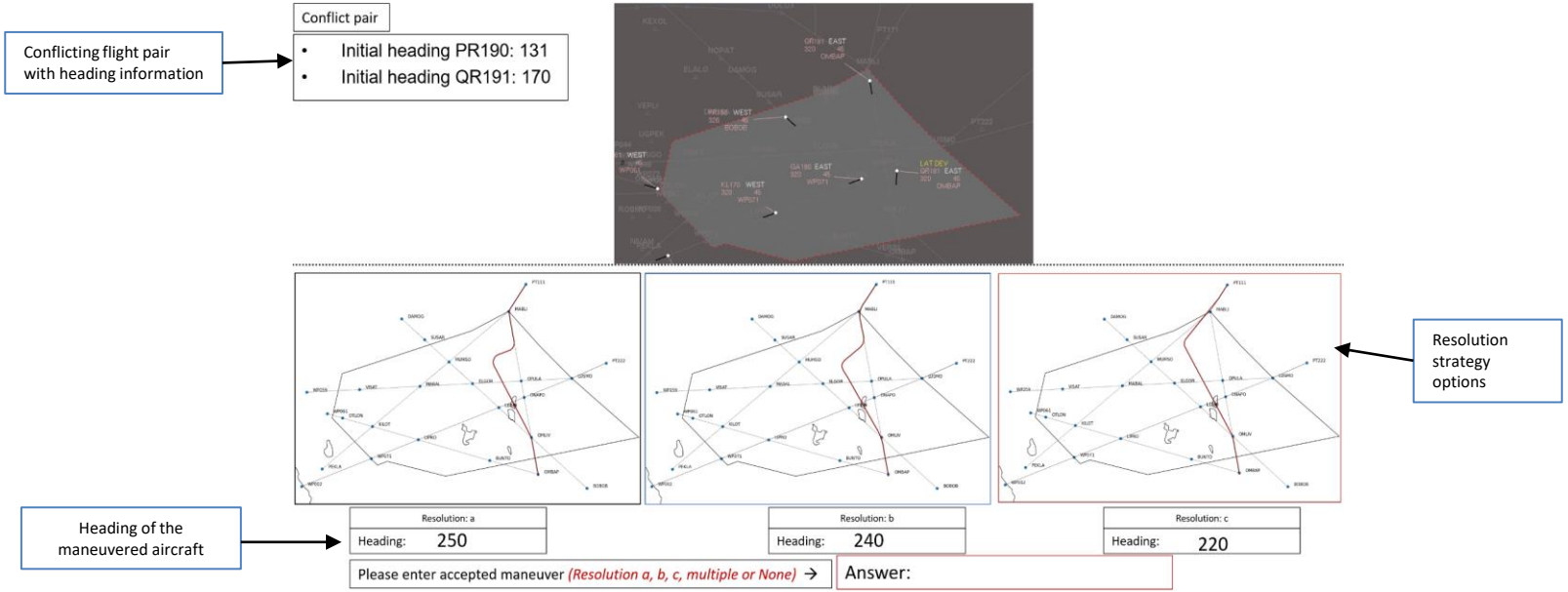


ATCO's conflict resolution maneuvers

Guleria, Y., Tran, P.N., Pham, D.T., Durand, N. and Alam, S. (2021), A Machine Learning Framework for Predicting ATC Conflict Resolution Strategies for Conformal Automation, SESAR Innovation Days (SID 2021).

ATCO Validation Exercise

- Evaluate the conformance of the ATCO preference with the identified ATCO strategies.
- Identify the extent of acceptance of ML predictions by the ATCOs



Guleria, Y., Alam, S, Phu, N.T., Pham D.T., and Durand, N. (2023) A Machine Learning Framework for Predicting Air Traffic Conflict Resolution Strategies for Conformal Automation, IEEE Transactions on Human-Machine Systems (Under review)

Summary

1. Machine Learning offers a data-driven paradigm, away from a rule-based automation.
2. Machine Learning enables human-driven conformal automation.
3. Machine Learning can assist Air Traffic Controllers to:
   - Handle complex traffic scenarios;
   - Augment human-cognition in complex decision making; and
   - Maintain situation awareness in a dynamic environment.

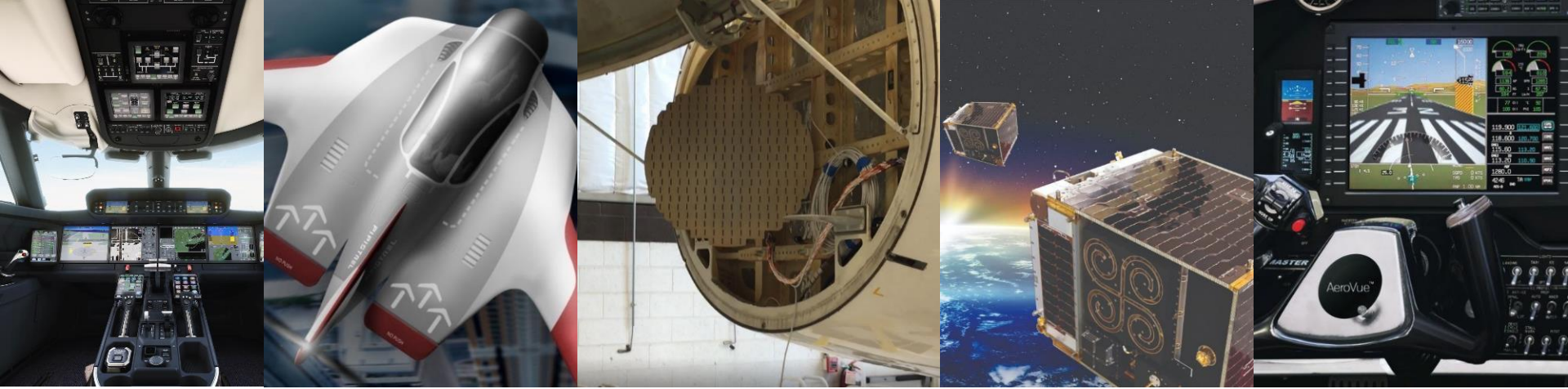
Thank you for your attention

sameeralam@ntu.edu.sg

AI use cases in aviation: Pilot assistance

Joeri DeRuytter, Honeywell Ambassador R&T

EASA



EASA AI DAYS 2023

On a path towards Human-AI teaming

Joeri De Ruytter
Advanced Technology

Honeywell

May 16th, 2023

Acknowledgement

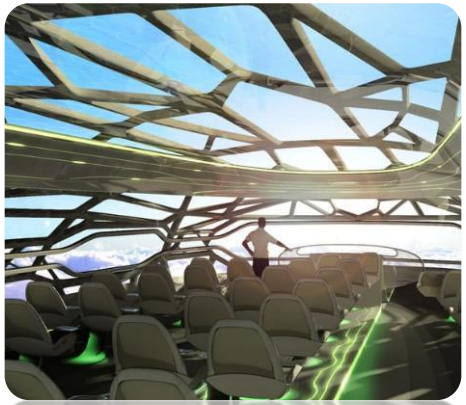
This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 945583. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Clean Sky 2 JU members other than the Union.

Disclaimer

The results, opinions, conclusions, etc. presented in this work are those of the author(s) only and do not necessarily represent the position of the JU; the JU is not responsible for any use made of the information contained herein.

WHAT DRIVES CURRENT AVIATION R&D?

Autonomy



Digitalization

AI & Trust

Welcome to a new era of flight — while safety still comes first!

WHY DO WE NEED AI IN COCKPIT ?

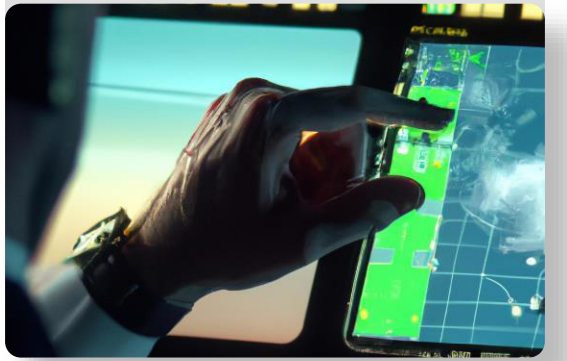
Current Cockpit Operations

- New interaction modalities
- Rule-based systems with reasoning
- Portable electronic devices

Simplified Cockpit Operations

- **Pilot state monitoring**
- Pilot assistants
- ATC compliance monitoring
- Certifiable machine learning and reasoning

More Autonomous Operations



- Intelligent assistants
- **Human-Machine teaming**

SOME OF THE CHALLENGES

Data representativeness

Ensure training data represents real life operational situations

Use case:
Pilot State Monitoring

Pilot–AI teaming

Ensure hybrid crew operates at the same (or higher) level of safety as the full human crew.

Use case:
More autonomous operations

DATA REPRESENTATIVENESS

	Variability in behavioral features Gender, age, ethnicity, etc.	Psycho- physiological signature variability Behaviors, Bio metrics	Aircraft conditions var. Camera location, Lighting, Dynamics
			
Training & test	Characteristics of data collection subjects	Medical Measurement and annotations Behavior in training / test conditions	Cockpit simulator specific test aircraft
	should be		
	representative of		
Execution	Actual pilot visual characteristics	Actual pilot state Behavior in real life	In flight use on any aircraft

HOW TO GAIN REPRESENTATIVE DATA

Scientific literature

Psycho-physiological response to sleep is well documented

Laboratory training and test

200+ hours of high-quality data collected from 60 subjects

Since 2019

Flight Test validation

B36 TC

Q2 2021

B757

Q4 2021

F900

Q3 2022

B757

Q4 2022

Collaboration with REPS*

* **R**eal Life **E**nvironment with **P**ilot State Monitoring **S**ystems

Full motion simulator

- Installation robustness
- Impact of aircraft dynamics on performance

Q2 2022

Data collection on revenue aircraft

2023

PILOT–AI TEAMING

AI Level 1
(PSM)

AI Level 1 & 2
(PSM, Assistants, collaboration)

ESSENTIAL CHARACTERISTICS OF PILOT-AI TEAMING COCKPIT

- **Clear roles & responsibilities**
  Pilot vs. AI: Human pilots remain ultimate decision maker
- **Sufficient level of performance, usability and explainability**
  Collaborative partnership between human and machine
- **Effective, efficient and robust mitigations**
  if AI fails

Honeywell preparing Pilot-AI teaming cockpit

ANY QUESTION?

Joeri De Ruytter
joeri.deruytter@honeywell.com

Honeywell

Discussion Panel
Autonomy : challenges ahead!

Moderator

Jean-Marc Cluzeau
EASA Head of Safety Intelligence

Speakers

Anna Von Groote
EUROCAE Director General

Romaric Redon
Airbus Head Advisor AI Technology

Marc Baumgartner
IFATCA EASA/SESAR Coordinator

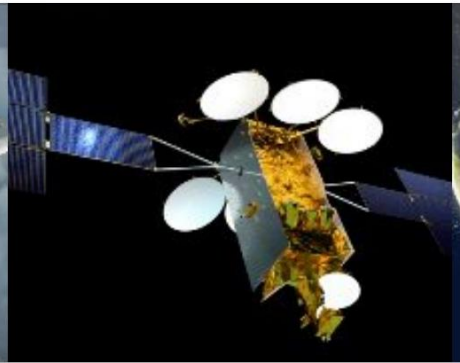
Thomas Krüger
DLR AI Institute Deputy Director



Airport/Airline Operational Improvements with AI

AIRBUS

Romaric Redon
AIRBUS
Artificial Intelligence
Fast track Leader

Make AI FLY roadmap

Level of autonomy

#Times Series Analysis

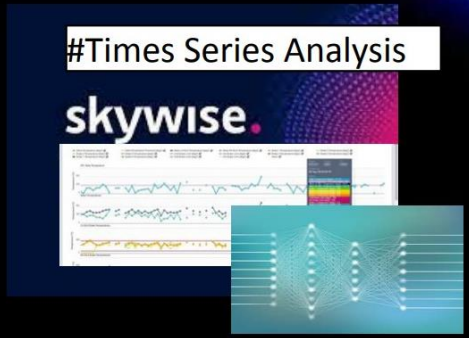
#Computer Vision

#NLP

#Decision making

#Computer Vision

#Times Series Analysis



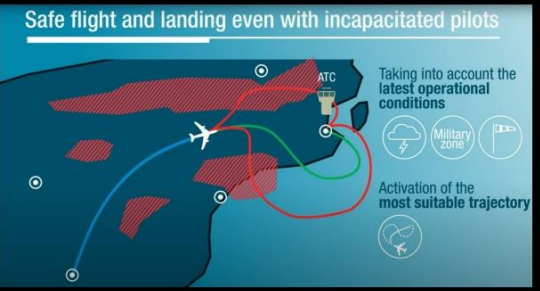
Level of criticality

AIRBUS

DragonFly - Airbus UpNext Demonstrator

UpNext

New pilot assistance and tools to support onboard decision-making
Making flying even safer and more efficient in complex ATM environment



Diversion assistance tool

Taxi

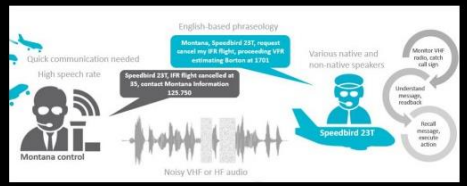
Assistances to manage crew workload

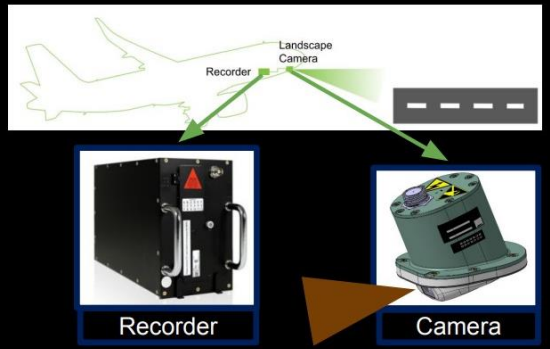
Landing

Generalised Autoland

MDC

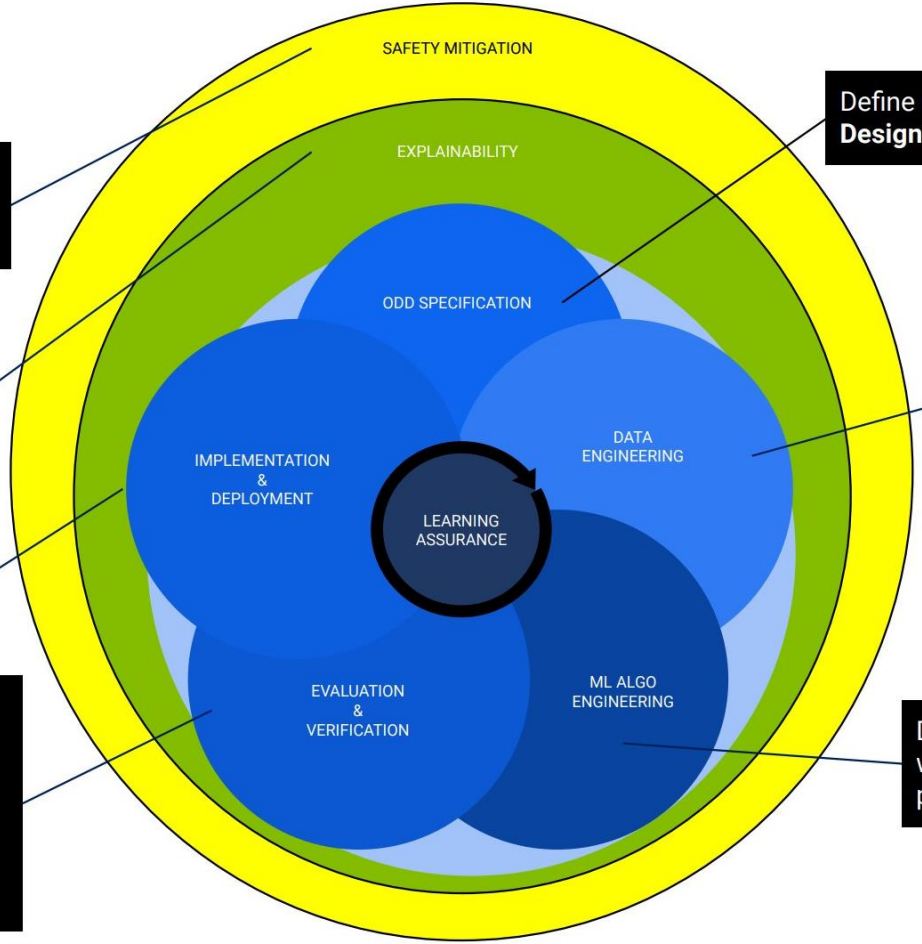
Massive Data Capitalization





AIRBUS

Challenges for certification AI based Autonomy (in a Nutshell)



Design efficient **Monitoring function** to switch to **Fallback** safe solution

Ensure **Explainability** targeting Developers, Users, Auditors

Ensure same perfo on embedded HW target
Ensure **Real-time perfo** (WCET)

Characterise perfo on ODD
Robustness (natural perturbation, adversarial attacks,...)
Stability (output not too sensitive to input perturbation)
Level of confidence (uncertainty estimation,...)

Define **Operational Design Domain**

Get the right data (**Representativeness, completeness**...) REAL & SYNTHETIC data

Demonstrate the model **generalise** well and (good prediction on previously unseen data)

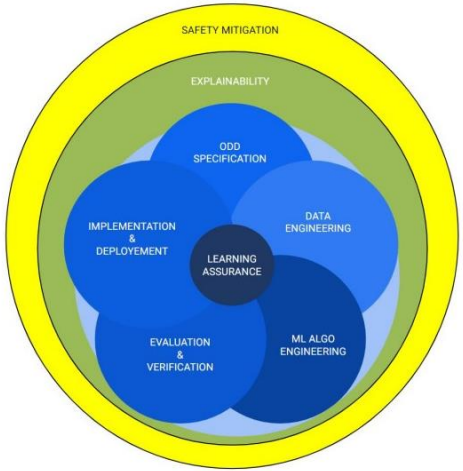
AIRBUS

CONCLUSION

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE TOULOUSE INSTITUTE

Confiance ai

DEEL
DEpendable & Explainable Learning



CENELEC

EUROCAE SAE INTERNATIONAL

ARP6983
ED-xxx
Certification
Approval
of Aeronautical
Safety-Related Products
Implementing AI

MLEAP

Trusted AI methods and tools

Safe and efficient introduction of AI in critical Systems

Standards

Requirement Ensuring Safe and Efficient operations

Academics + Tech companies

Industrials

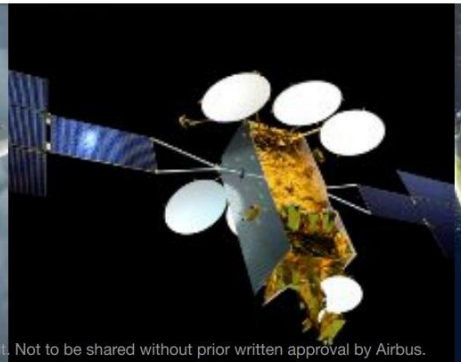
Regulation authorities



Scale AI to boost competitiveness

AIRBUS

World leader in Safe and Trustworthy AI

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DLR AI Institute Deputy Director

« Autonomy: challenges ahead » .

Marc Baumgartner SESAR / EASA coordinator IFATCA

Contents

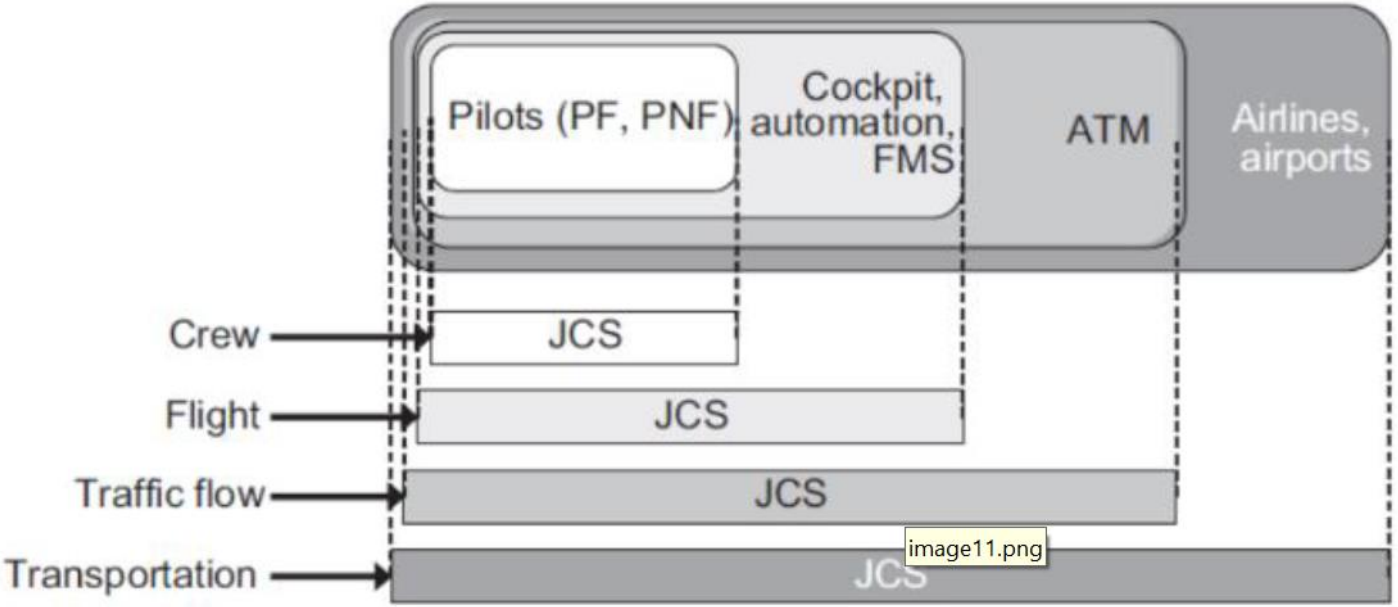

Figure 3-1: The traffic flow Joint Cognitive System (Hollnagel, 2007).

Assumed Benefits	Real Complexity
Increased performance is obtained from "substitution" of machine activity for human activity.	Practice is transformed; the roles of people change; old and sometimes beloved habits and familiar features are altered—the envisioned world problem.
Frees up human by offloading work to the machine.	Creates new kinds of cognitive work for the human, often at the wrong times; every automation advance will be exploited to require people to do more, do it faster, or in more complex ways—the law of stretched systems.
Frees up limited attention by focusing someone on the correct answer.	Creates more threads to track; makes it harder for people to remain aware of and Integrate all of the activities and changes around them—with coordination costs, continuously.
Less human knowledge is required.	New knowledge and skill demands are imposed on the human and the human might no longer have a sufficient context to make decisions, because they have been left out of the loop, automation surprise.
Agent will function autonomously.	Team play with people and other agents is critical to success—principles of interdependence.
Same feedback to human will be required.	New levels and types of feedback are needed to support peoples' new roles—with coordination costs, continuously.
Agent enables more flexibility to the system in a generic way.	Resulting explosion of features, options, and modes creates new demands, types of errors, and paths toward failure—automation surprises.
Human errors are reduced.	Both agents and people are fallible; new problems are associated with human agent coordination breakdowns; agents now obscure information necessary for human decision making—principles of complexity.

Table 1-1: Myths about assumed benefits of Technology

Joint View – the way forward

- Separate or Joint – The current paradigm and the joint view?
    - o We do not expect that technology can take over the control of traffic in the coming decades.
- Increasing complexity, uncertainty and surprises.
- Staying in control
- Technology is also humans – the integrated view.
    - o Controllers, designers, and engineers not only use the technology; they are they the technology!

- A new definition of levels of automation.
    - o There is no scale. It is more a description of a flow how we achieve functions.

- Automation – What does it mean? o The left-over strategy
    - o People are the technology.

- Responsibility and the consequences of the paradigm change
    - o how we treat the human in general

- The radical change doesn't mean that we can't increase the use of technology. It is about looking at the world through a different lens.
- The efficiency and sustained adaptability trade off.
- Control and adaptability.

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DLR AI Institute Deputy Director

INSTITUTE FOR AI SAFETY & SECURITY

EASA AI Days 2023
Panel Discussion on Autonomy
Dr. Thomas Krüger

DLR

From Automation to Autonomy

- Increased capablities for AI-based decision making by the systems
- Connectivity between systems
- Increased traffic density within the airspace
- Interconnections between traffic modes
- Exposure to cybersecurity threats

→ Integrated and complex system of systems

→ How to manage complexity over the life-cycle?

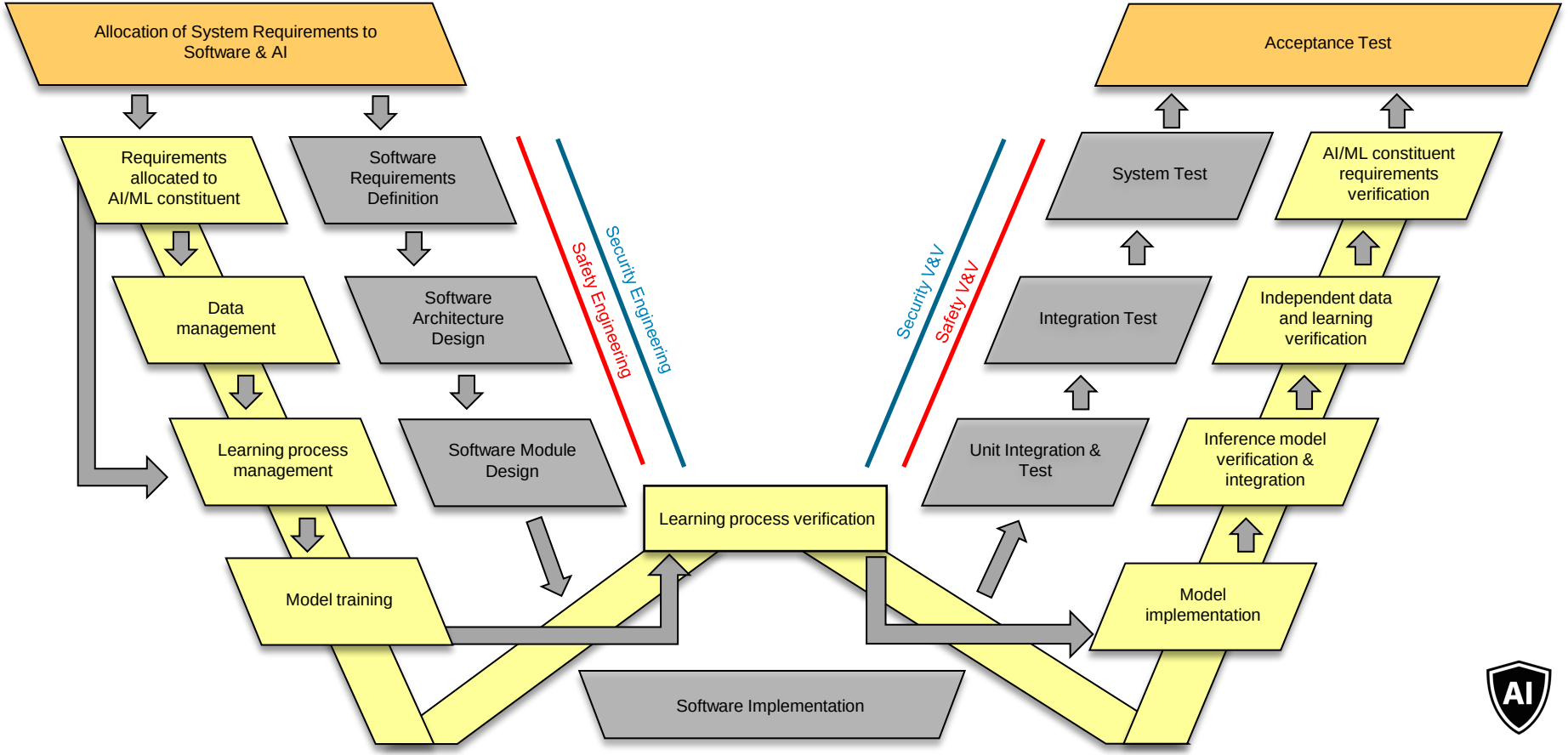
→ Synergies with other domains like automotive or space?

Some of the Challenges to Address

- (Model-based) AI Systems Engineering and integration of AI functions into system architectures
- Designing learning algorithms with increased explainability and quantifiable robustness
- Data quality and synthetic data
- High-performance onboard hardware
- Digital Twin architectures
- Cybersecurity (AI vs. AI?)
- Resilience and failure response capabilities
- Non-technical aspects of trustworthy AI
- Certification

- Life-cycle management of AI-based systems
- Learning during operation

A Starting Point – Establish AI Systems Engineering.



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DLR AI Institute Deputy Director

European and International Standardisation of Artificial Intelligence in Aviation

Anna von Groote

EASA AI Conference – 16 May 2023 –Cologne

EUROCAE AI Standardisation

- **Address aviation stakeholder needs by developing high-quality standards**
  - Built upon state-of-the-art expertise
  - Fit for purpose
  - Adopted internationally
  - Support operations, development and regulations
  - Address emerging global aviation challenges

- **TWP**
  - Strategic standardisation plan
  - Updated annually by TAC
  - By the Members – For the Members

WG-114/G-34 Artificial Intelligence

Objectives

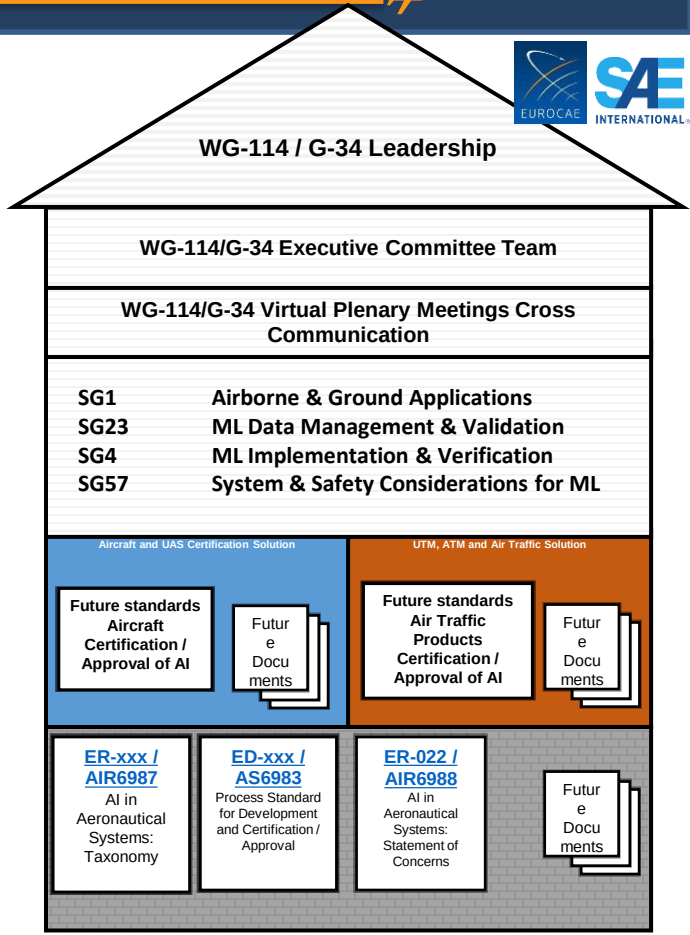
- Develop a comprehensive statement of concerns
- Develop standards and reports for selecting, implementing and certifying AI technology within aeronautical systems
- Act as a key forum for enabling the global adoption and implementation of AI technologies
- Enable aerospace manufacturers and regulatory agencies to consider and implement to the certification of AI systems

Scope

- Airborne (Aircraft, UAS) & Ground (ATM, UTM)

Deliverables

- ER-022 Statement of concerns
- ER-xxx Taxonomy in AI (exp Q2/2023)
- ER-xxx Use Cases Considerations (exp 2024)
- ED-xxx Process Standard for Development and Certification/Approval of Aeronautical Products Implementing AI (exp 2024)

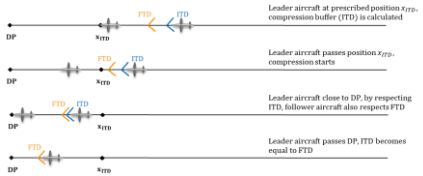


WG-114/G-34 Use cases

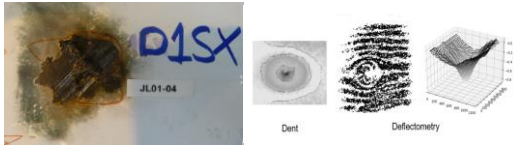
ER-xxx: Use Cases on Non-adaptive AI Technology

Related domains: Flight Operations and Communications, CNS/ATM for both manned, unmanned aircraft and ground systems

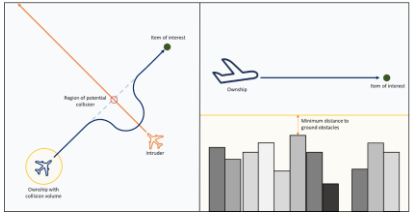
Safe Autonomous Flight Termination (SAFETERM)



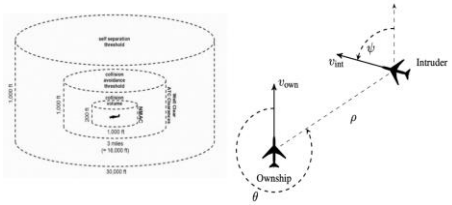
Time-based Separation (TBS)



Automated Visual Inspection - Airbus



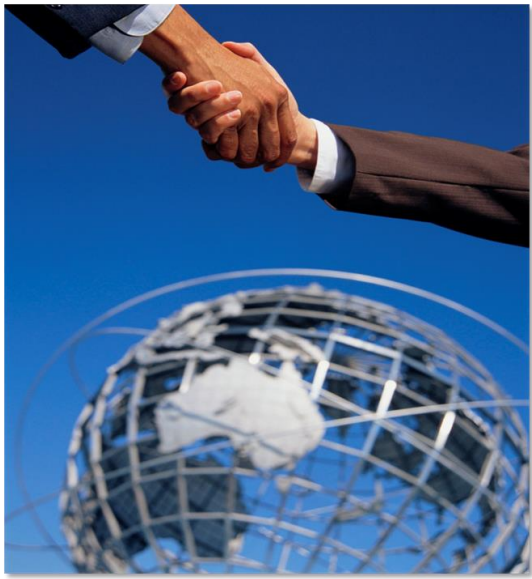
Maneuver Planning



Next Generation Airborne Collision Avoidance System

AI Standardisation

- **Standards have to be seen in the overall AI ecosystem**
  - Early coordination
  - Timely availability of standards
  - Mutual understanding and common success
- **Partnerships amongst SDOs**
  - Avoid duplications and overlaps
  - Make best use of resources
- **Industry – SDO – authority collaboration**
  - Strong engagement and close alignment
  - Efficient compliance demonstration methods



EUROCAE

THANK YOU

Anna von Groote

Director General

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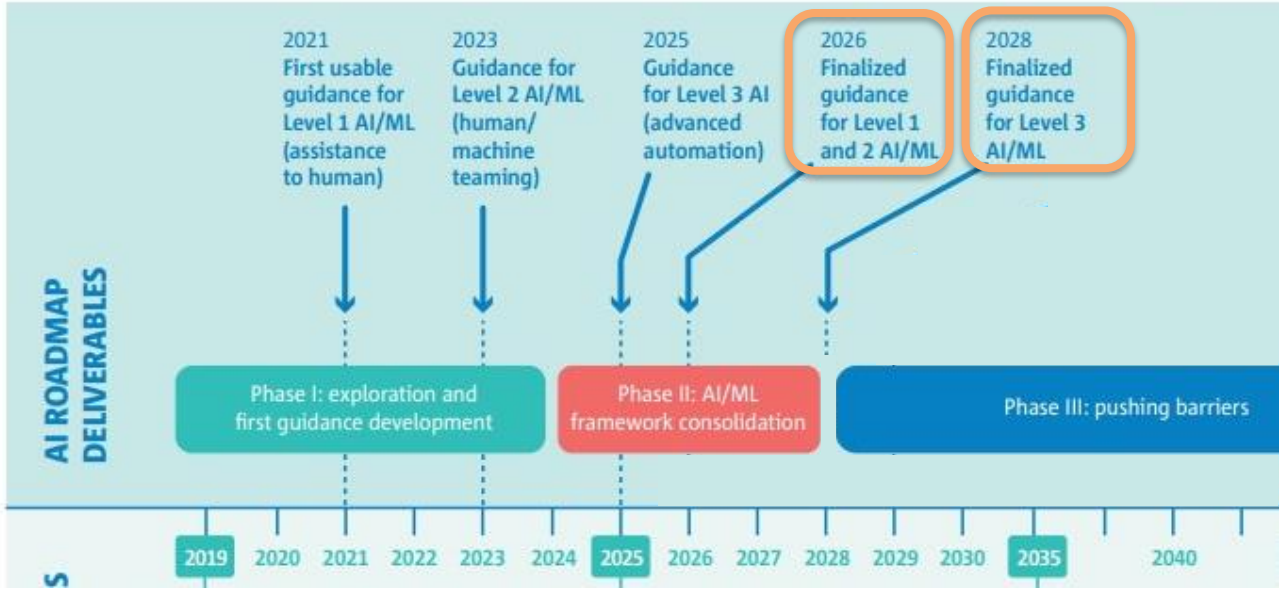
DLR AI Institute Deputy Director

Rulemaking concept for AI

Michael Gerhard – EASA Safety Programmes Section Manager

EASA

Anticipating the consolidation phase II



EASA Regulatory framework

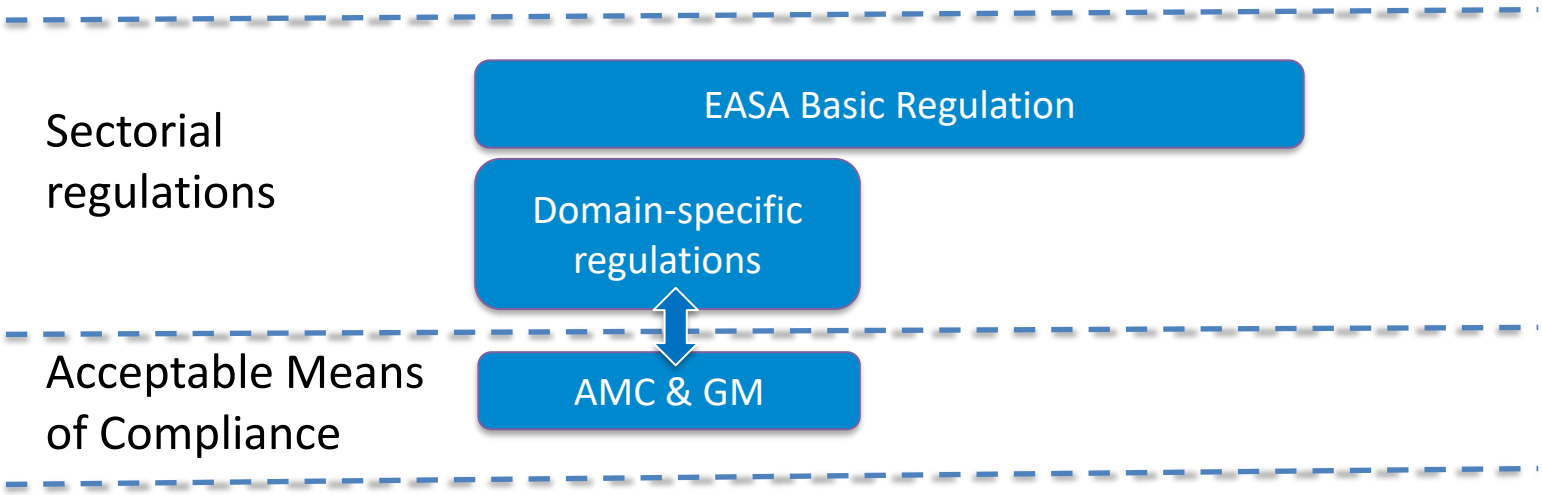
Regulations are supported by:

Acceptable means of compliance (AMC) and **guidance material** (GM)

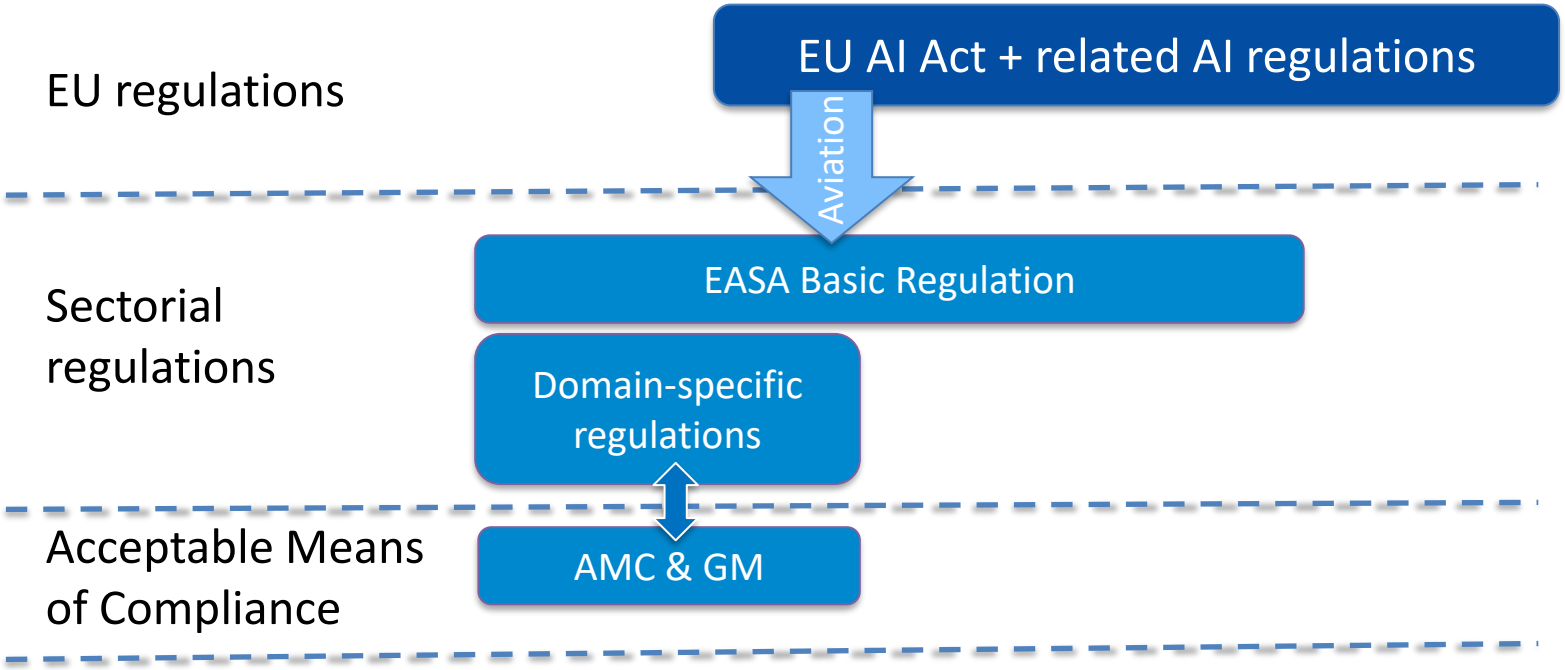
Certification Specification (CS) for the certification of aircraft/engines/...

Special Conditions (SC) for new design not covered by CS

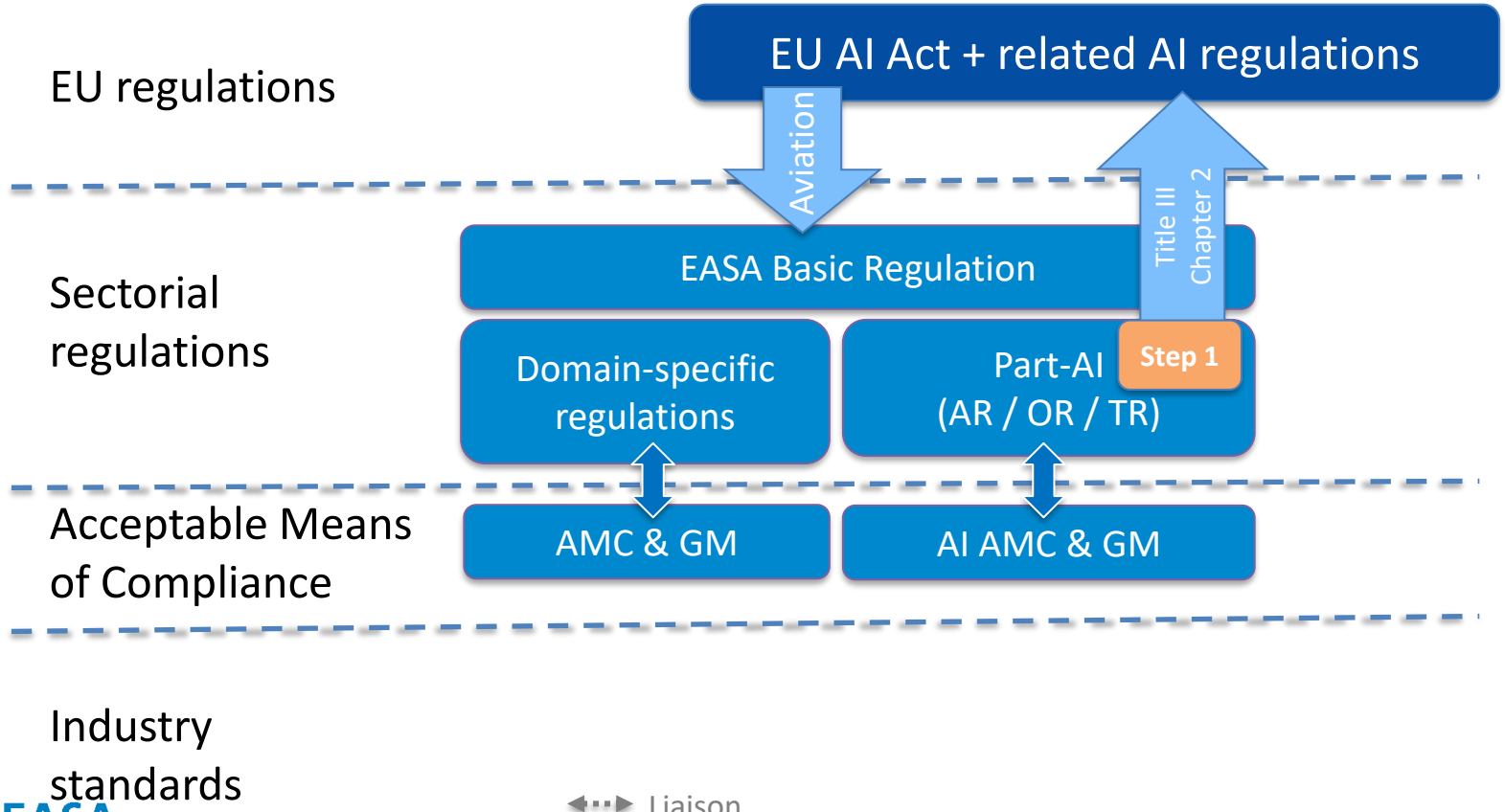
Rulemaking concept for AI



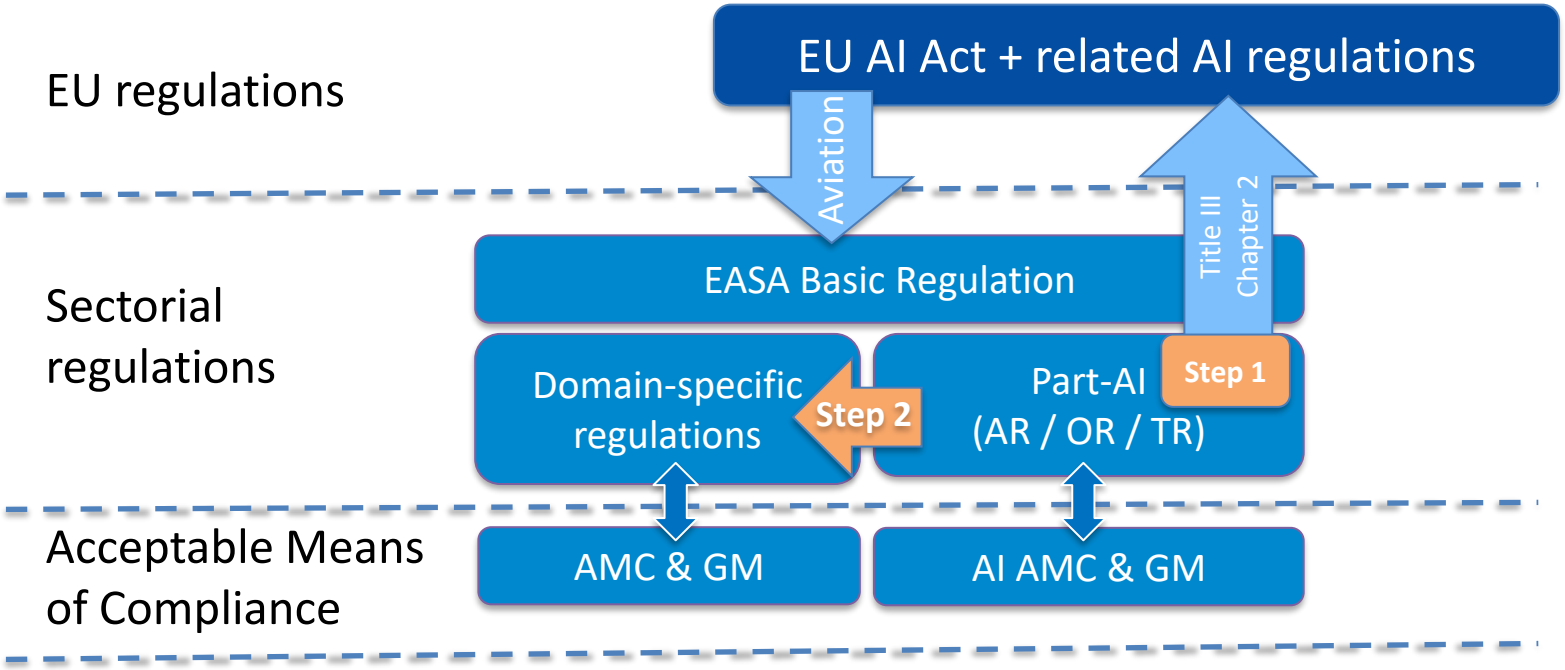
Rulemaking concept for AI



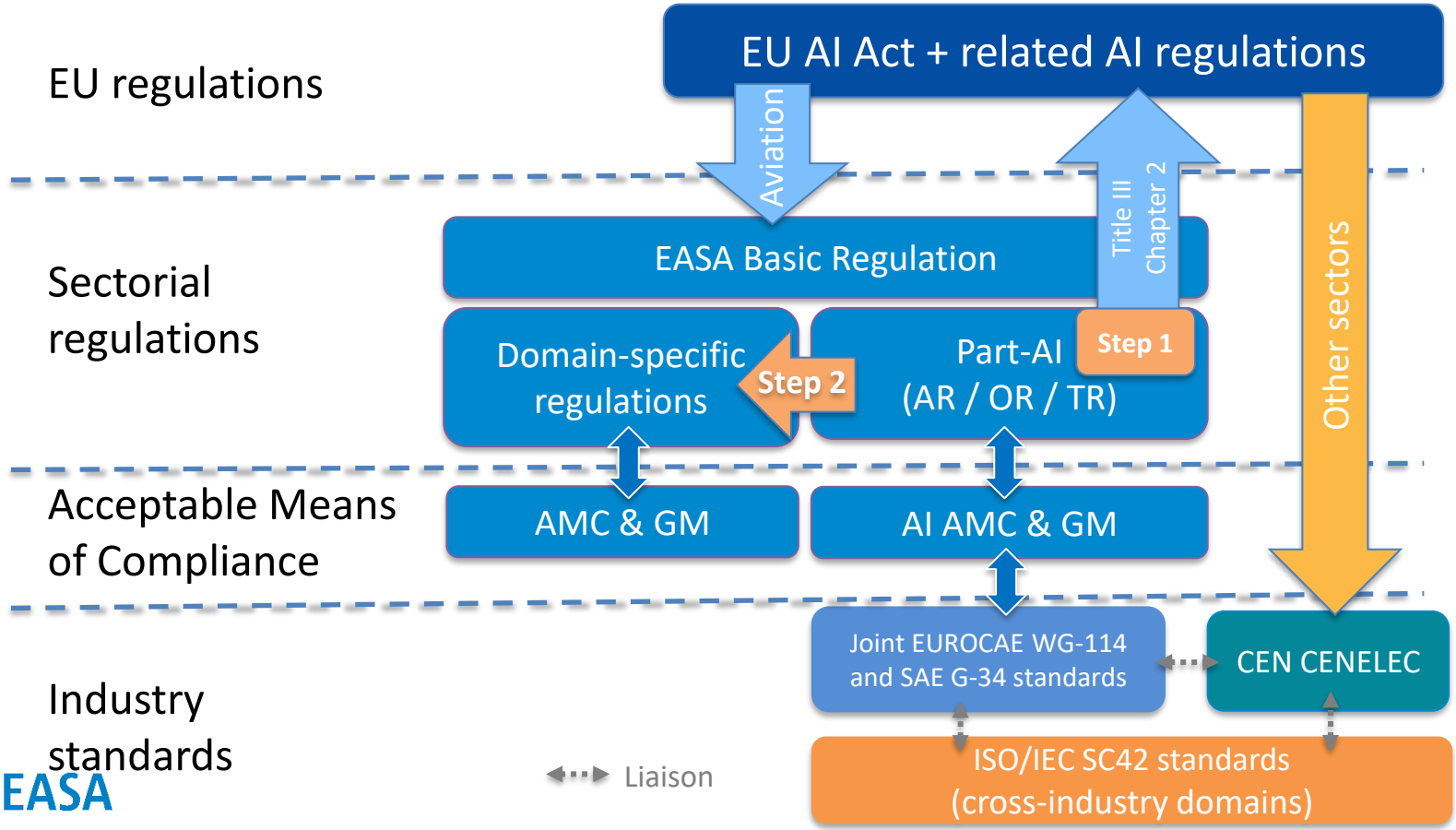
Rulemaking concept for AI



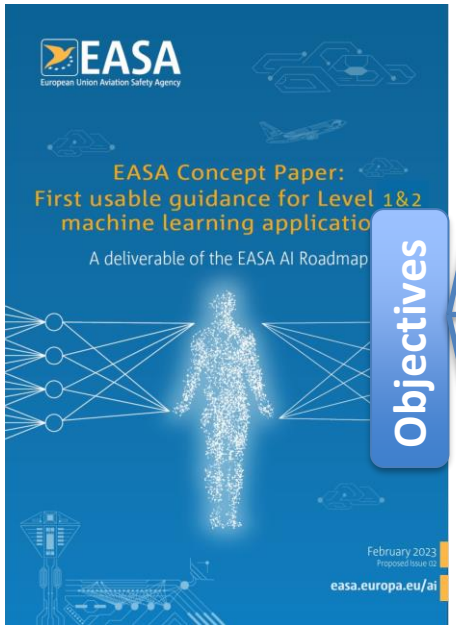
Rulemaking concept for AI



Rulemaking concept for AI



Anticipated scope of the future Part-AI



Objectives

Part-AI.TR
Trustworthiness
Requirements

- Data governance & management
- Technical robustness
- Safety and Security
- Transparency
- Human Oversight...

Part-AI.OR
Organisations requirements

- Auditability
- Risk management system
- Continuous assessments
- Training

Part-AI.AR
Authorities Requirements

- Support to competent authorities (e.g. EASA, NSAs in ATM)

EASA AI Days High-Level Conference
Wrap-up and conclusions

Jesper Rasmussen – EASA Flight Standards Director

EASA

Thank you for your participation!

Let’s continue the discussion…
Get together @ Gaffel am Dom 19:30 – 22:30

Any question?

Please contact us: ai@easa.europa.eu