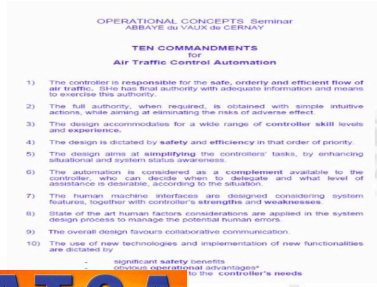
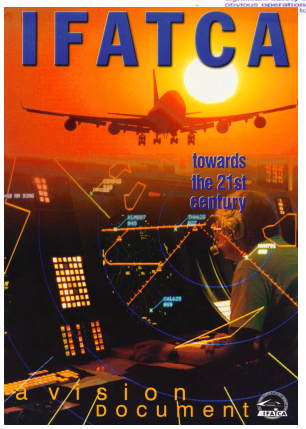
What is required from AI to bring the ATM sector beyond automation of housekeeping tasks?

Marc Baumgartner
SESAR / EASA coordinator
IFATCA


OPERATIONAL CONCEPTS Seminar
ABBAYE du VAUX de CERNAY

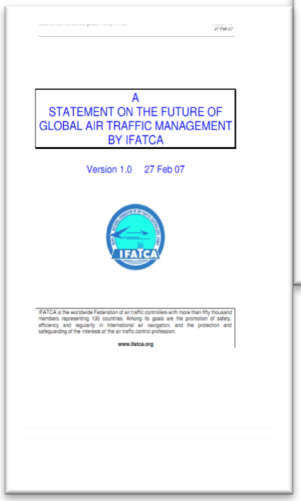
TEN COMMANDMENTS
for
Air Traffic Control Automation

1) The controller is responsible for the safe, orderly and efficient flow of air traffic. S/He has final authority with adequate information and means to exercise this authority.
2) The full authority, when required, is obtained with simple intuitive actions, while aiming at eliminating the risks of adverse effect.
3) The design accommodates for a wide range of controller skill levels and experience.
4) The design is dictated by safety and efficiency in that order of priority.
5) The design aims at simplifying the controllers' tasks, by enhancing situational and system status awareness.
6) The automation is considered as a complement available to the controller, who can decide when to delegate and what level of assistance is desirable, according to the situation.
7) The human machine interfaces are designed considering system features, together with controller's strengths and weaknesses.
8) State of the art human factors considerations are applied in the system design process to manage the potential human errors.
9) The overall design favours collaborative communication.
10) The use of new technologies and implementation of new functionalities are dictated by
- significant safety benefits
- obvious operational advantages
to the controller's needs



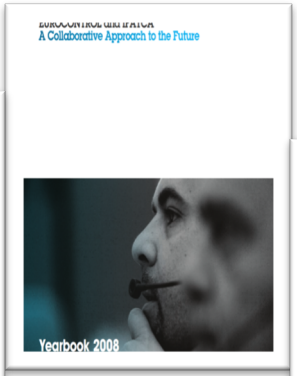
2003

1997-98

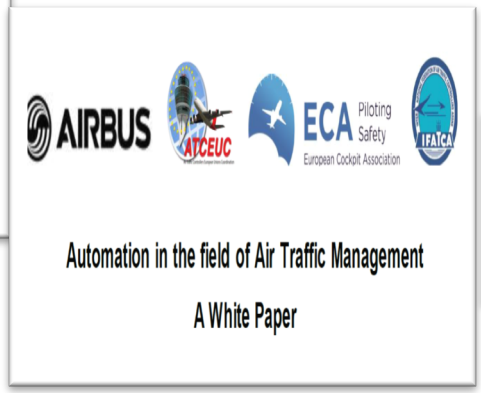

A
STATEMENT ON THE FUTURE OF GLOBAL AIR TRAFFIC MANAGEMENT BY IFATCA

Version 1.0 27 Feb 07

2007



2008



2015

2015

2017/18

31.1.2018

10.10.2018

1.2.2019

The operator in the future system

Possibilities and limitations of new technology

Digitalisation in ATM – Joint Human Machine System The only way forward?

https://www.ifatca.org/digitalisation-in-air-traffic-management/

Digitalization of infrastructure – a few basics

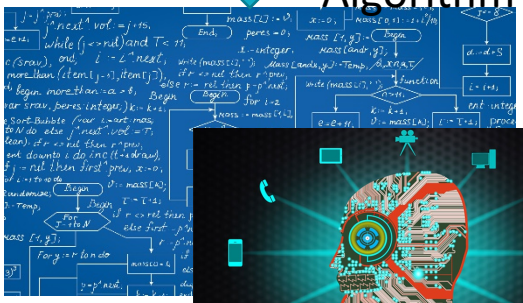
Prof. Montero in Network Industries/quarterly 12/2020 No 22
https://cadmus.eui.eu/bitstream/handle/1814/69295/NIQ%20Vol%2022%20-%20Issue%204%20-%20December%202020%20final.pdf?sequence=1

Source: IT magazine

Source: dw.com

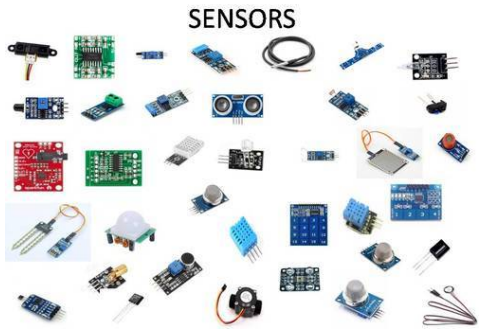
Data layer being laid over the top of reality

Algorithm



Source: IT magazine

Artificial Intelligence



Source: intenet

Availability Underlying Infrastructure

Source: satta.ch

Source: intenet

Digitalization of infrastructure – a few basics

Prof. Montero in Network Industries/quarterly 12/2020 No 22 https://cadmus.eui.eu/bitstream/handle/1814/69295/NIQ%20Vol%2022%20-%20Issue%204%20-%20December%202020%20final.pdf?sequence=1

Source: IT magazine

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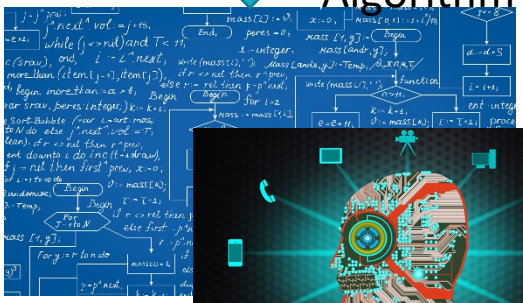
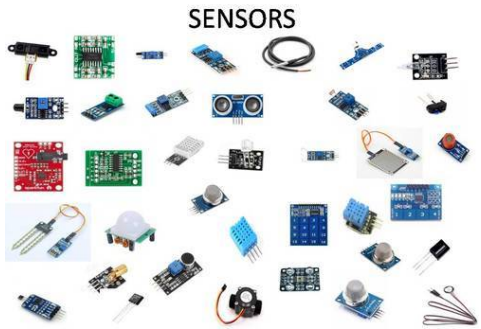


Source: IT magazine

Artificial Intelligence



Source: intenet

Availability Underlying Infrastructure

Source: satta.ch

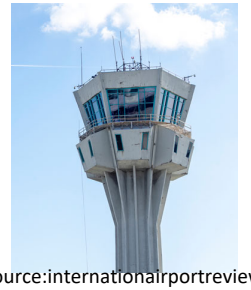
Mirror image of reality

Source: intenet

Digitalization of infrastructure – a few basics – cost reduction – applied to ATM

Prof. Montero in Network Industries/quarterly 12/2020 No 22

Cost reduction in the design & construction of infrastructure



Source:internationalairportreview

Cost reduction in infrastructure maintenance

Source: skynews.ch

Cost reduction in charging for infrastructure use

Source: enav

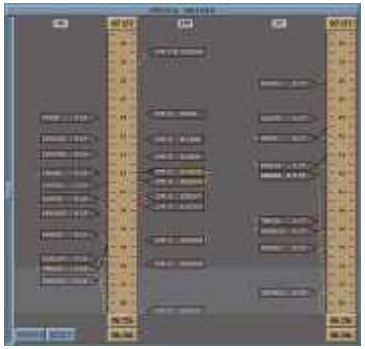
Cost reduction in infrastructure operations

Source: imansolas

Source:DFS

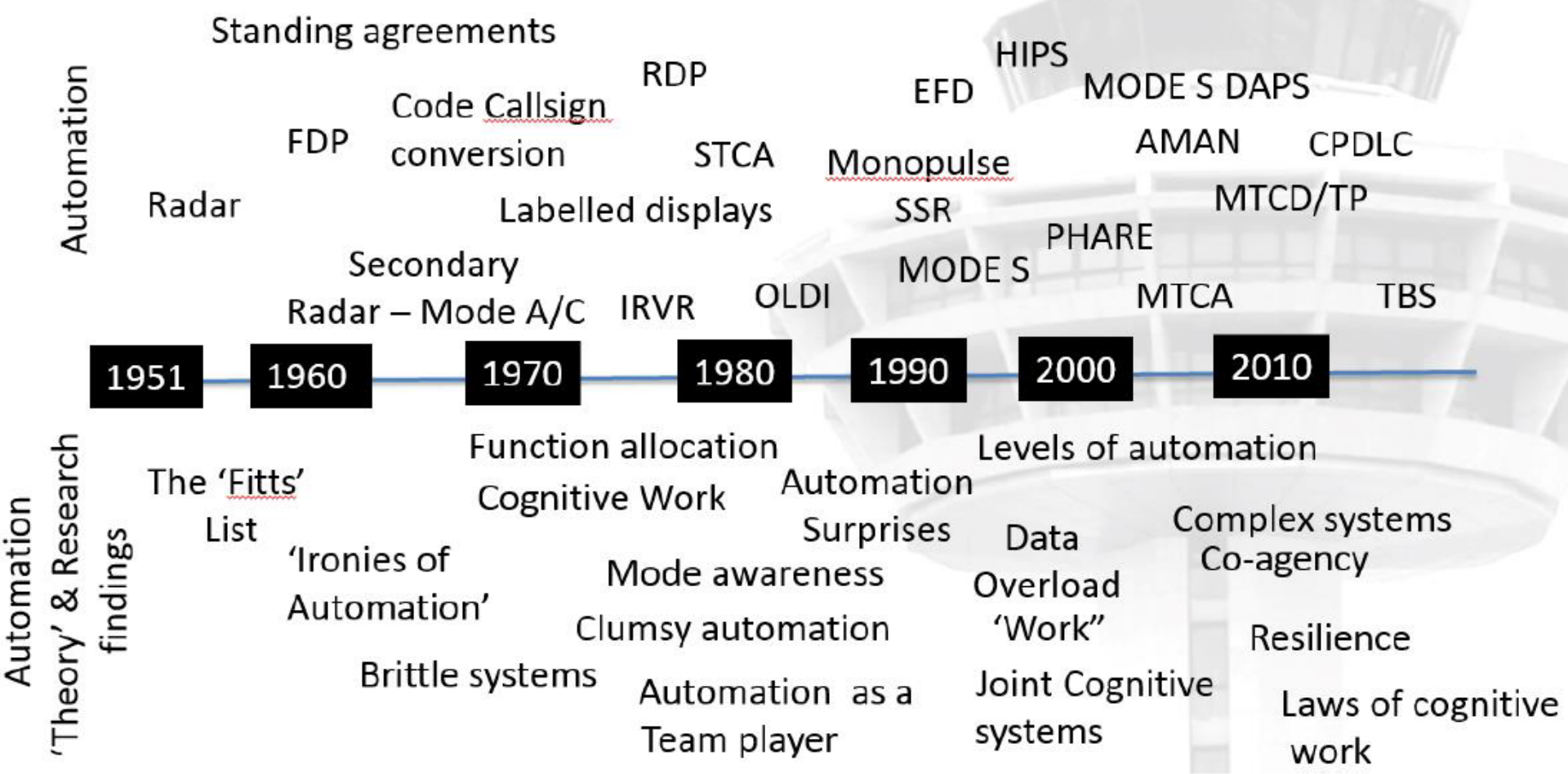
Source: Mozworks

Source: avinor



Source: Eurocontrol phare

Automation in ATM



Source: A.Smoker

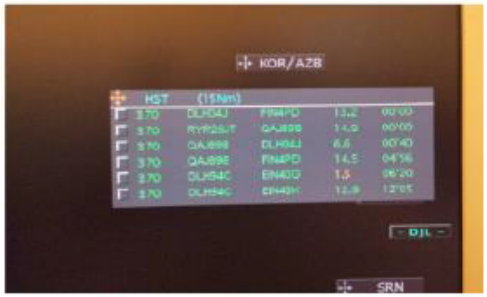
House keeping in ATM?

A
STATEMENT ON THE FUTURE OF GLOBAL AIR TRAFFIC MANAGEMENT BY IFATCA

Version 1.0 27 Feb 07

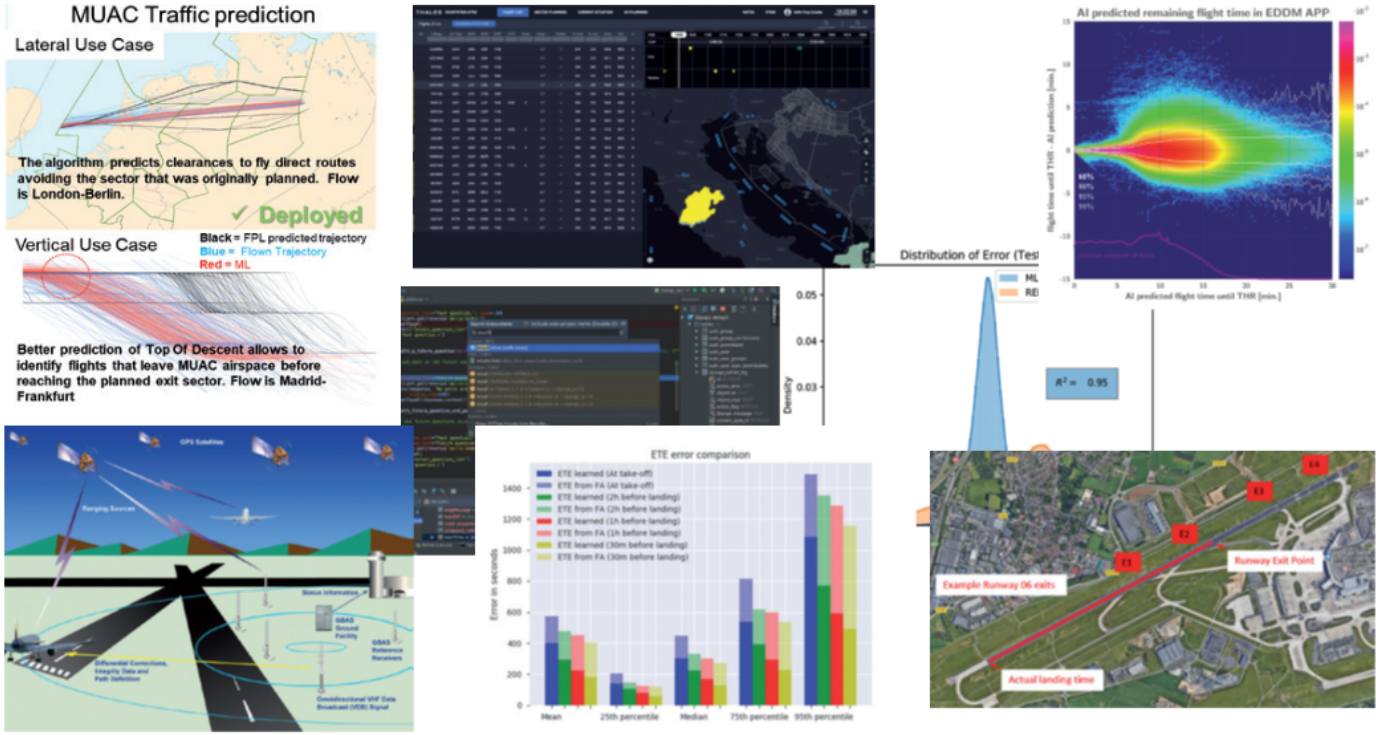
IFATCA is the worldwide Federation of air traffic controllers with more than fifty thousand members representing 135 countries. Among its goals are the promotion of safety, efficiency and regularity in international air navigation, and the protection and safeguarding of the interests of the air traffic control profession.

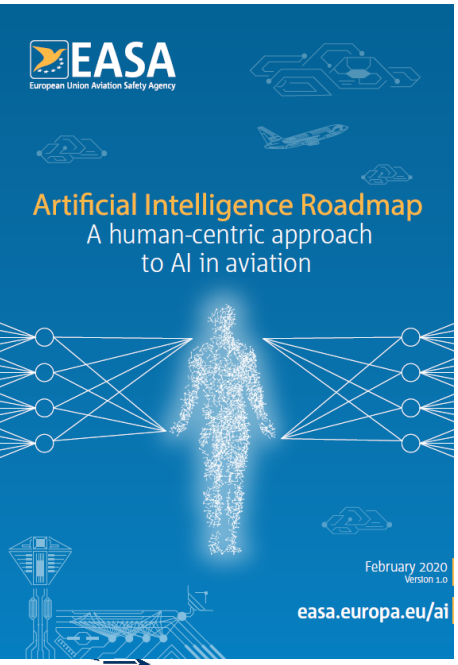
www.ifatca.org



My work place has
MTCD
CLAM (MONA)
WHAT IF
MULTI-SECTOR PLANNER
WHATSUP WITH A/C (CPDLC)
CLEARANCE VERIFICATION
E-COORDINATION
REPLAY

BUT it is only in my center!





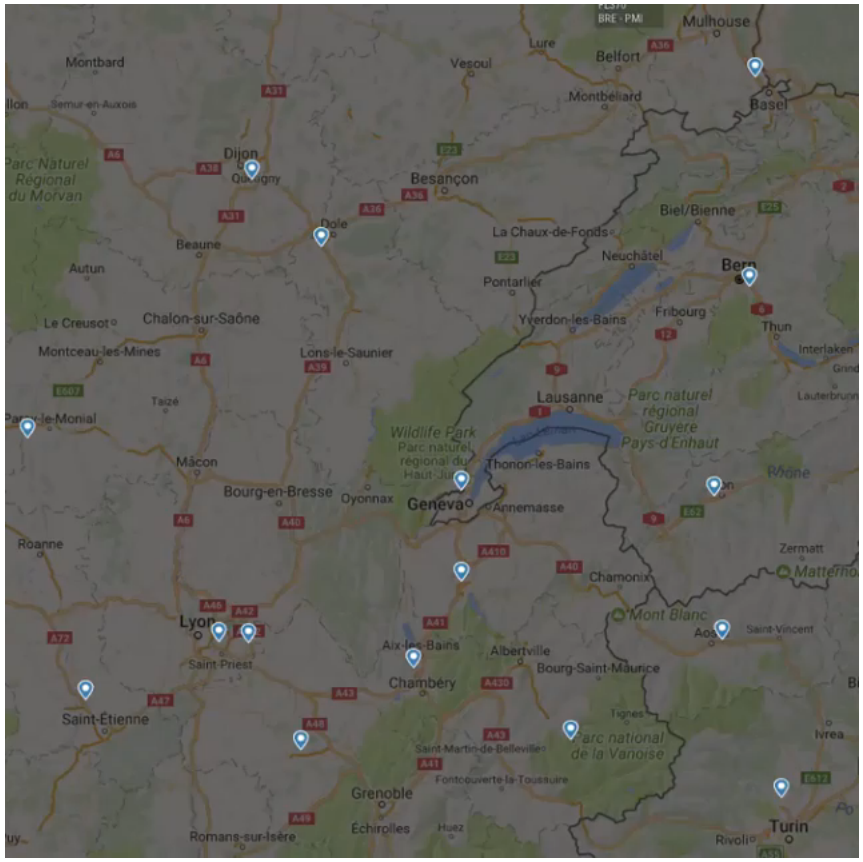
AI in ATM

	A	B	C
1	17	UC-SC301	Multiple UAS or Manned Aircraft Prioritizing Airspace Access Request
2	18	UC-SC302	Unexpected Bad Weather in flight path of UAS
3	19	UC-SC303	Unexpected Terrain in the flight path of the UAS
4	20	UC-SC304	Go-Around Prediction
5	21	UC-SC305	Air Traffic Control Routing
6	22	UC-SC306	Training of Operators (ATC)
7	23	UC-SC307	Air Traffic Flow Management
8	24	UC-SC308	Time-Based Separation
9	25	UC-SC309	Remote Towers
10	26	UC-SC310	Ground Operations Taxi
11	27	UC-SC311	Taxi to Runway Operations
12	28	UC-SC312	Fuel-Efficient Runway Affectation with RL
13	29	UC-SC313	Fuel-efficient Runway affectation
14	30	UC-SC314	ATC System sends auto routing commands to UAS.
15	31	UC-SC315	Voice to text
16	32	UC-SC316	Voice or text to intent
17	33	UC-SC317	Target Detection, Classification and Identification

EUROCAE

IFATCA

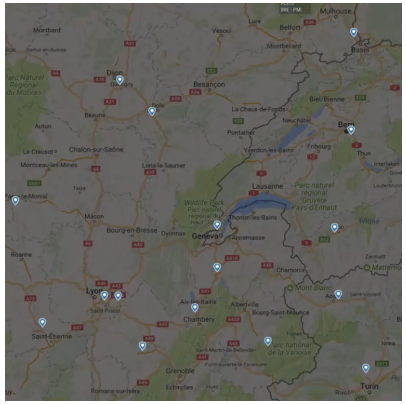
AI for safety-critical systems



Same level horizontal separation

Source: X.Comte

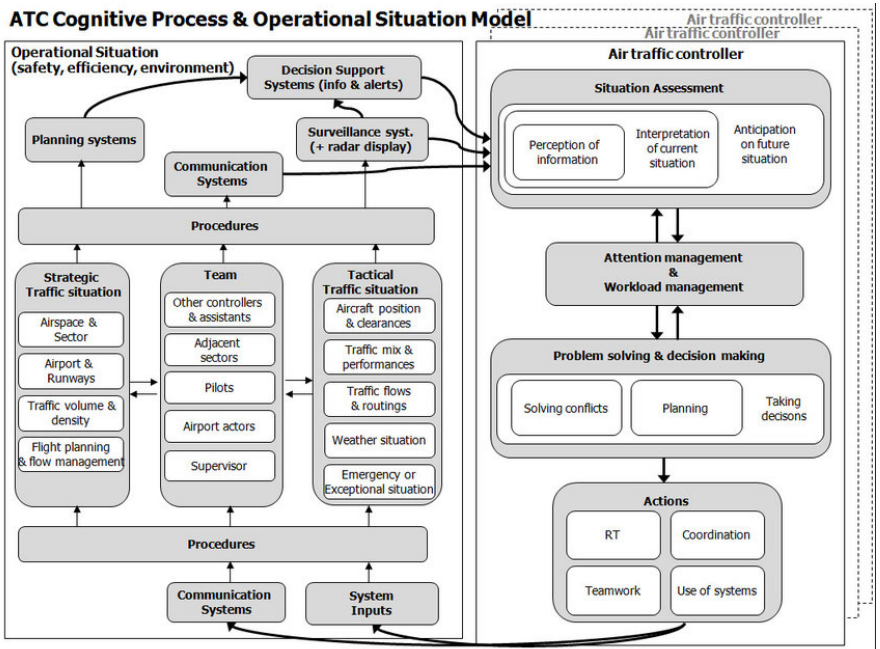
AI for safety-critical systems



Source: X.Comte

	Conflict	Mngr	(10Nm)	v
■	DEVTP	5.9 nm	EZS31DF	10 min
■	EZY36MD	5.7 nm	DEVTP	——
■	TAR700	1.8 nm	EZS31DF	07 min
■	BAW730	0.6 nm	EZS31DF	07 min

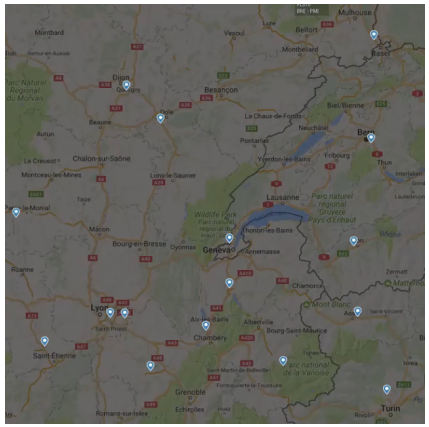
Source: skyguide



Source:Marian Schuver- van Blanken

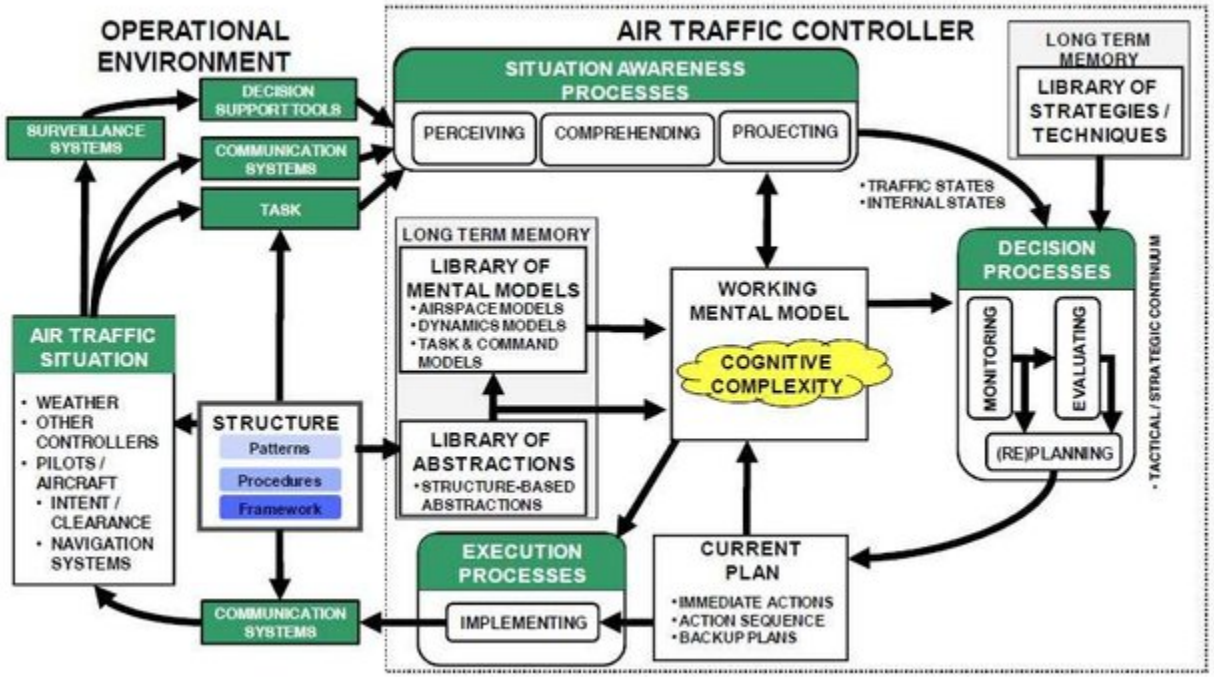
Same level horizontal separation

AI for safety-critical systems



Source: X.Comte

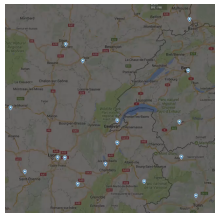
- Prototype solutions
- A lot of cognitive workload for the ATCOs
- Housekeeping tasks increase
- Workload increases – and limits capacity



Source: Histon

Same level horizontal separation

AI for safety-critical systems



Same level horizontal separation

PREDICTION OF CONFLICT FREE TRAJECTORIES USING SUPERVISED MACHINE LEARNING, INITIAL INVESTIGATIONS

Raphaël Christien, Karim Zeghal, Eric Hoffman
EUROCONTROL Experimental Centre, France

Abstract

This paper presents initial investigations

Introduction

This paper presents initial investigations regarding the prediction of conflict free aircraft trajectories using supervised machine learning. The motivation is to investigate the feasibility of conflict resolution based on historical data, mimicking controller resolution patterns from similar traffic situations (imitation learning).

We follow the approach recently developed for predicting mobiles future positions, taking into account their contextual information including surrounding mobiles, in the domain of self-driving vehicles [1]. This approach relies on a deep learning model, a classical convolutional neural network

Source: Christien, Hoffman, Zeghal

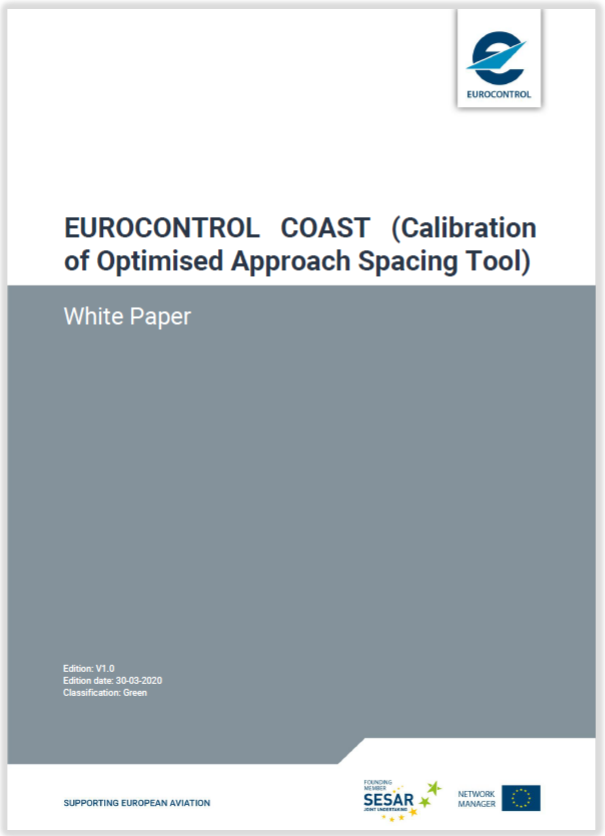
Human Factors and Aerospace Safety 5(1) 23-42 **FINAL DRAFT**

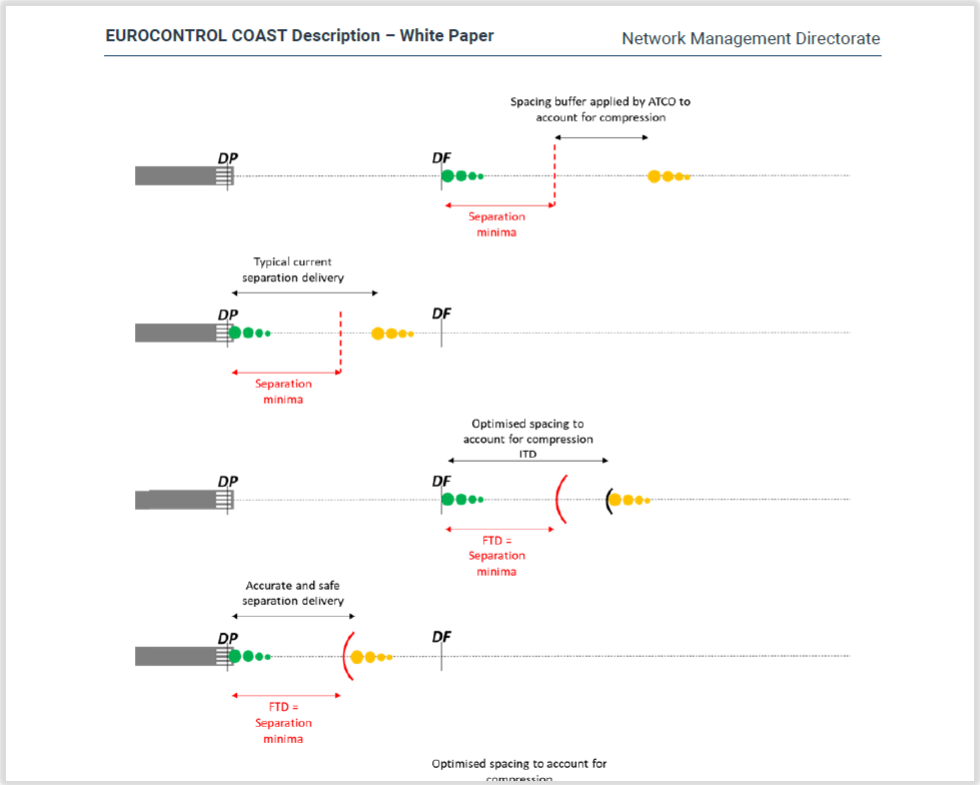
Air Traffic Control automation: for humans or people?

CORA

Peter Brooker
Cranfield University, UK

AI for safety-critical systems





AI for safety-critical systems

proceedings

MDPI

Proceedings

Predicting Airplane Go-Arounds Using Machine Learning and Open-Source Data †

Benoit Figuet [1,*], Raphael Monstein [1], Manuel Waltert [1] and Steven Barry [2]

1 Centre for Aviation, School of Engineering, Zurich University of Applied Sciences, 8401 Winterthur, Switzerland; raphael.monstein@zhaw.ch (R.M.); manuel.waltert@zhaw.ch (M.W.)
2 Safety and Assurance, Airservices Australia, Canberra, ACT 2601, Australia; steven.barry@airservicesaustralia.com
* Correspondence: benoit.figuet@zhaw.ch
† Presented at the 8th OpenSky Symposium 2020, Online, 12–13 November 2020.

Published: 1 December 2020

check for updates

Abstract: Go-arounds (GAs) are standard air traffic control procedures during which aircraft approach a runway but do not land. The incidence of a GA can subsequently affect the worklo crews and air traffic controllers, and might impact an airport runway's throughput capa study, two different modeling methods for predicting the occurrence of GAs based on o Automatic Dependent Surveillance–Broadcast (ADS-B) and meteorological data are A macroscopic model quantifies the probability of a GA within the next hour for an applying a generalized additive model. A microscopic model employs a number of machi

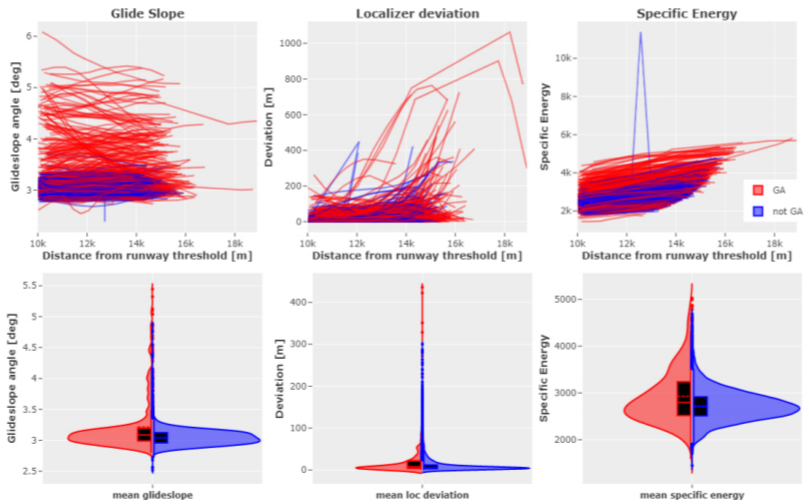


Figure 6. Profile of stability metrics and mean distributions.

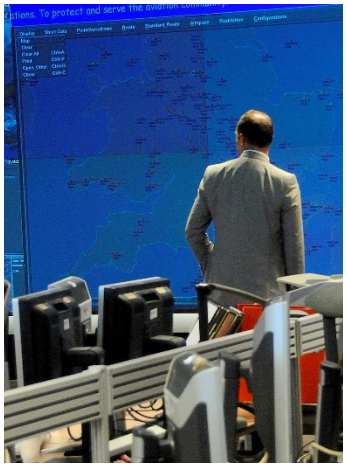
AI for safety-critical systems

ATM is decision making in an uncertain environment

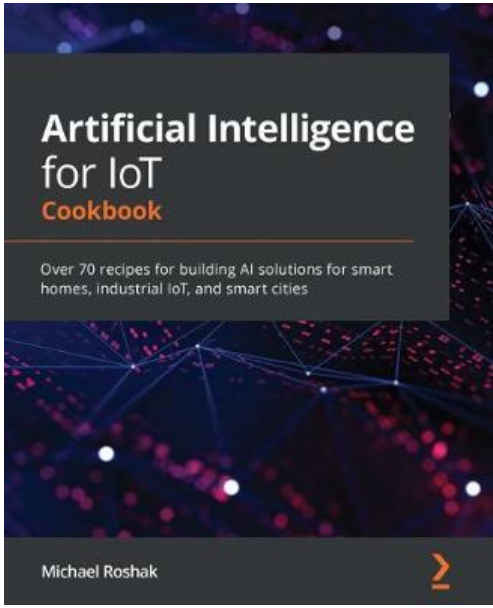
Source: FRAPORT

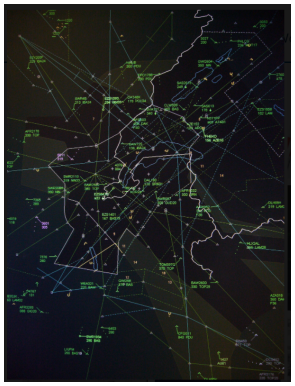
Figure 3: Cross-reference of paper work at the gate.

Source: Nomura et al.,



Source: NM





Source:skyguide

AI for safety-critical systems

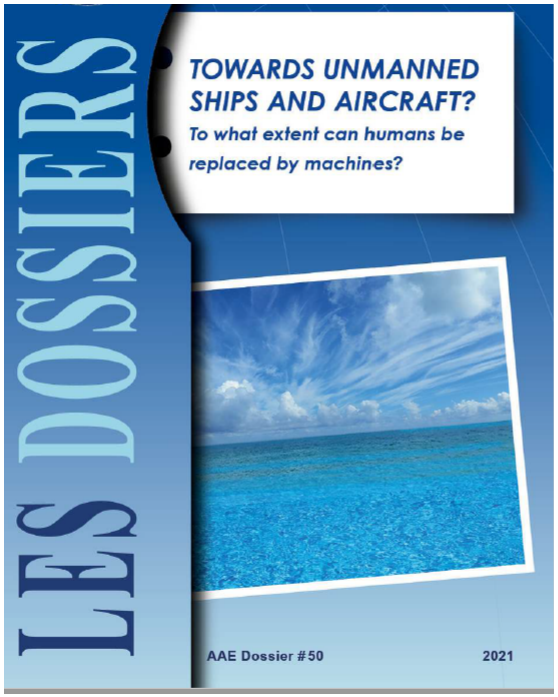
ATM is decision making in an uncertain environment

3.4 Will artificial intelligence meet future requirements?

Today, starting from a situation report provided by the information system, the autonomous operation of the vehicle is controlled by deterministic algorithms covering all imagined events or situations requiring the triggering of a predetermined reaction. Depending on the applications requested, these software programmes can correspond to varying degrees of quality, security and reliability. They can only respond to anticipated situations. The use of artificial intelligence, in particular deep learning (often qualified as non-deterministic), is often mentioned as the basis of tomorrow's embedded intelligence, due to its ability to interpret a considerable amount of data and to deduce optimised behavioural strategies from an almost infinite number of possible solutions.

However, it throws up important questions related to the existence of a probability of error and uncertainty intrinsic to these concepts. By construction, artificial intelligence software can only interpret situations and act according to its learned data. Accumulating data for a multitude of events, including the least likely, will require an "infinite" amount of time and memory in order to enable such systems to handle the unexpected. The testing and validation-certification capacity of such software will face identical difficulties, with validation and certification all the more difficult since the system will over time build its own experience and its modes of reasoning which, at the current stage, are mostly without rational explanation.

For as long as cooperation is expected between onboard artificial intelligence and a human operator, whether on board or on land, the logic of the automated system will need to be fully intelligible to the operator, which should rule out the use of non-deterministic processes in driving or piloting functions involving the safety of the vehicle for a very long time.

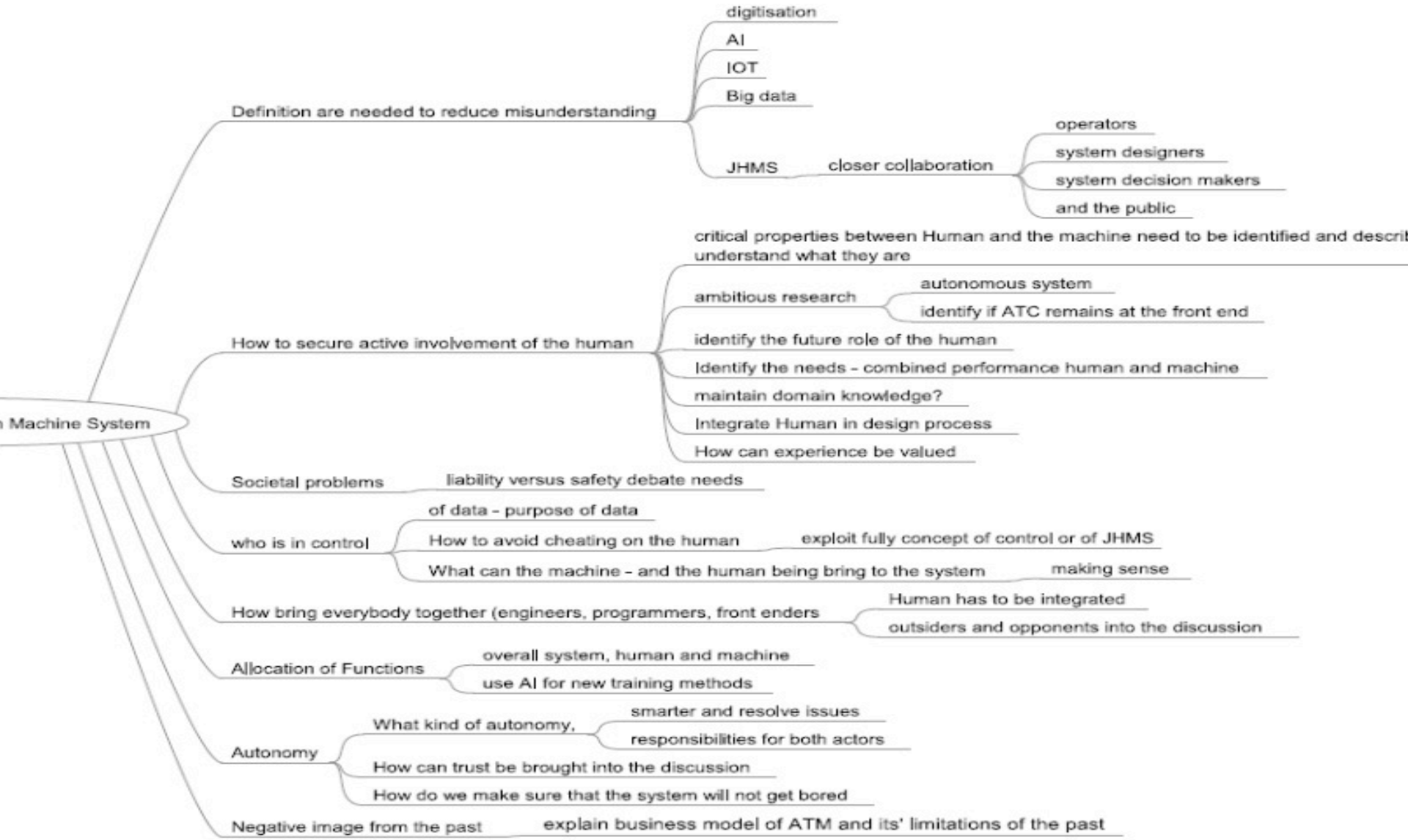


11.2 Towards an evolution of the law?

The evolution towards vehicle autonomy is of particular concern to the legal profession since this reality is recognised by law (law on mobility).

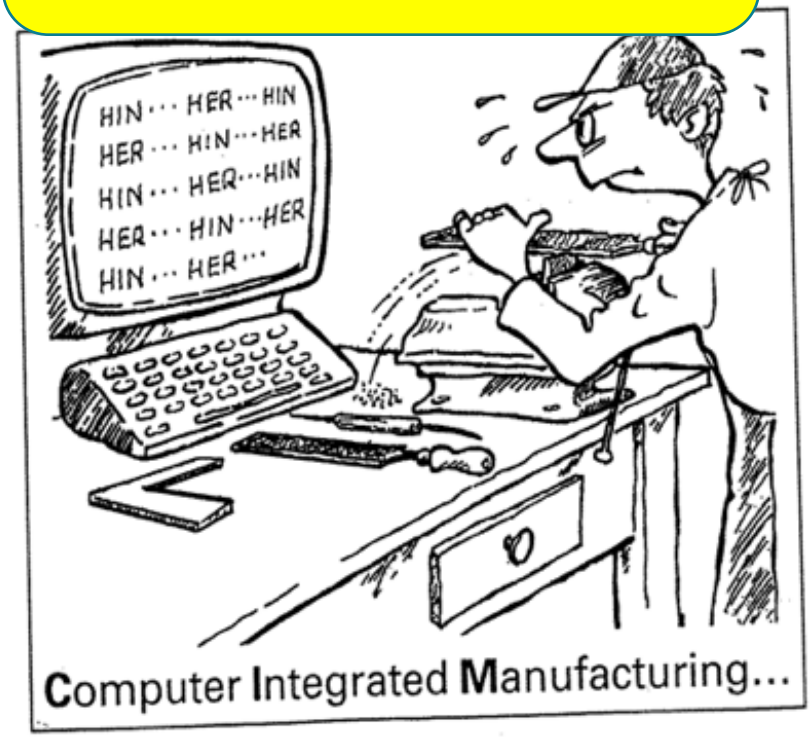
Consequently, two schools of thought oppose each other:

- *one considers that lawyers must go ahead and create, as of now, a new type of legal personality for robots, in order to support, but also to secure and legitimise, technical development. However, simply observing that the degree of intelligence of the most developed systems today does not exceed that of an ant is enough to render this thesis unrealistic for a long time to come;*
- *the other believes that the law guarantees social stability thanks to the continuity of legal concepts. The set of norms with which we live enable us to resolve a large part of any problems arising and to answer the essential questions thrown up by technological development. According to this category of jurists, it is therefore useless to create new concepts. It should be left up to judges to develop the interpretation of texts in a way that accompanies scientific evolution.*


Machine System
Definition are needed to reduce misunderstanding
digitisation
AI
IOT
Big data
JHMS
closer collaboration
operators
system designers
system decision makers
and the public
How to secure active involvement of the human
critical properties between Human and the machine need to be identified and describ
understand what they are
ambitious research
autonomous system
identify if ATC remains at the front end
identify the future role of the human
Identify the needs - combined performance human and machine
maintain domain knowledge?
Integrate Human in design process
How can experience be valued
Societal problems
liability versus safety debate needs
who is in control
of data - purpose of data
How to avoid cheating on the human
exploit fully concept of control or of JHMS
What can the machine - and the human being bring to the system
making sense
How bring everybody together (engineers, programmers, front enders
Human has to be integrated
outsiders and opponents into the discussion
Allocation of Functions
overall system, human and machine
use AI for new training methods
Autonomy
What kind of autonomy,
smarter and resolve issues
responsibilities for both actors
How can trust be brought into the discussion
How do we make sure that the system will not get bored
Negative image from the past
explain business model of ATM and its' limitations of the past

Joint: Human and Machine

Human vs. Machine
Human manages Machine
Or vice versa

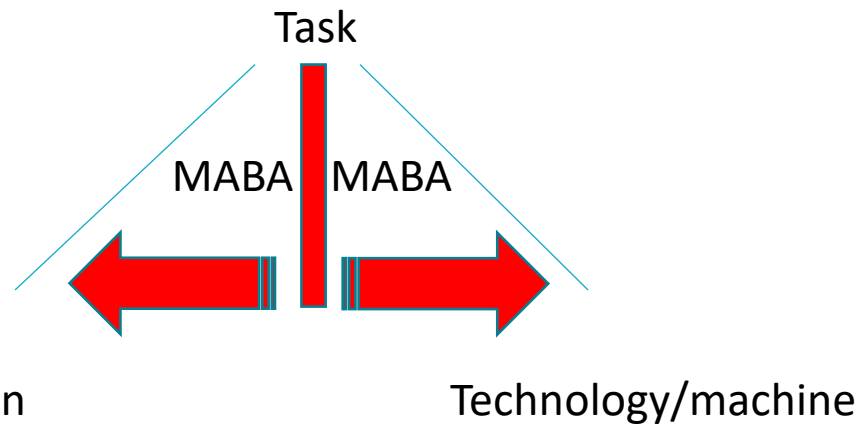


Human and Machine
Complementarity of
Human and Machine

Hyundai

Traditional Approach to implementing new technology

Men-Are-Better-At/Machines-Are-Better-At



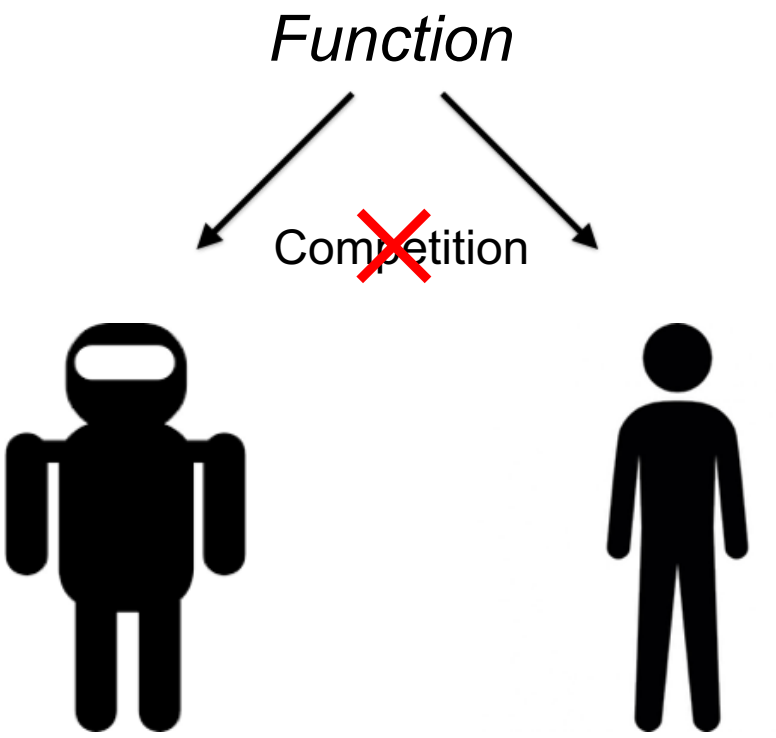
Fitts, P.M. (ed) (1951). Human engineering for an effective air-navigation and traffic-control system. National Research Council, Washington, D.C.

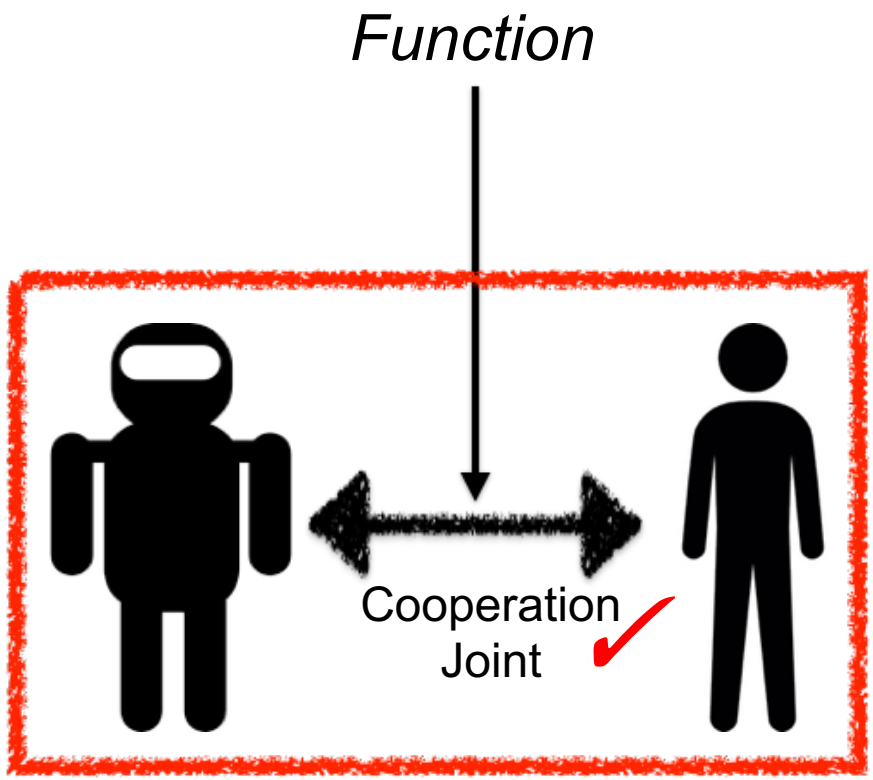
Function Allocation

(Wäfler et al., 2003)

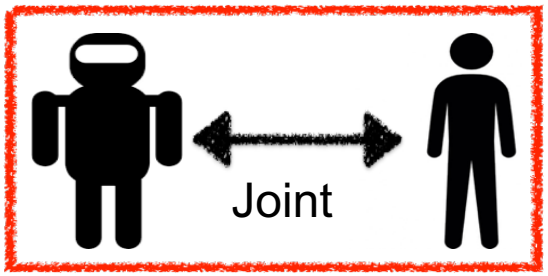
Human vs. Machine
Human manages Machine
Or vice versa

Human and Machine
Complementarity of
Human and Machine





The Human Contribution



- Verification of technical decisions
- Improving technical system
- Learning from technical system

- Manage uncertainty

- Take responsibility
- Show commitment and dedication

- …
- Empathy, creativity, improvisation

Preconditions

Clear human role in the system

Respective system design
- Avoiding deskilling
- Allowing continuous development of expertise (80% tacit)

- Job design required
- Ergonomics, UI/UX not enough

- Participatory approach a must

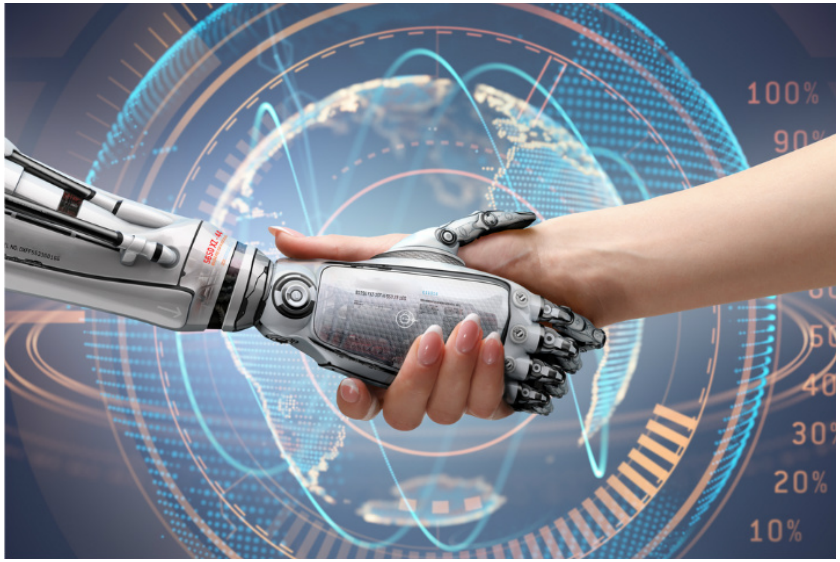
(Brynjolfsson & McAfee, 2017; Faust, 2007; Floridi, 2015, Manzey, 2012; Samek et al., 2017; Shively et al., 2017, Wäfler at al., 2003)

The Joint Human Machine System goal

Closer collaboration between operators, system designers, system decision makers and the public

Human and machine complement each other to achieve system goals

A humanistic design that allows humans to recover from the rare high-risk scenarios



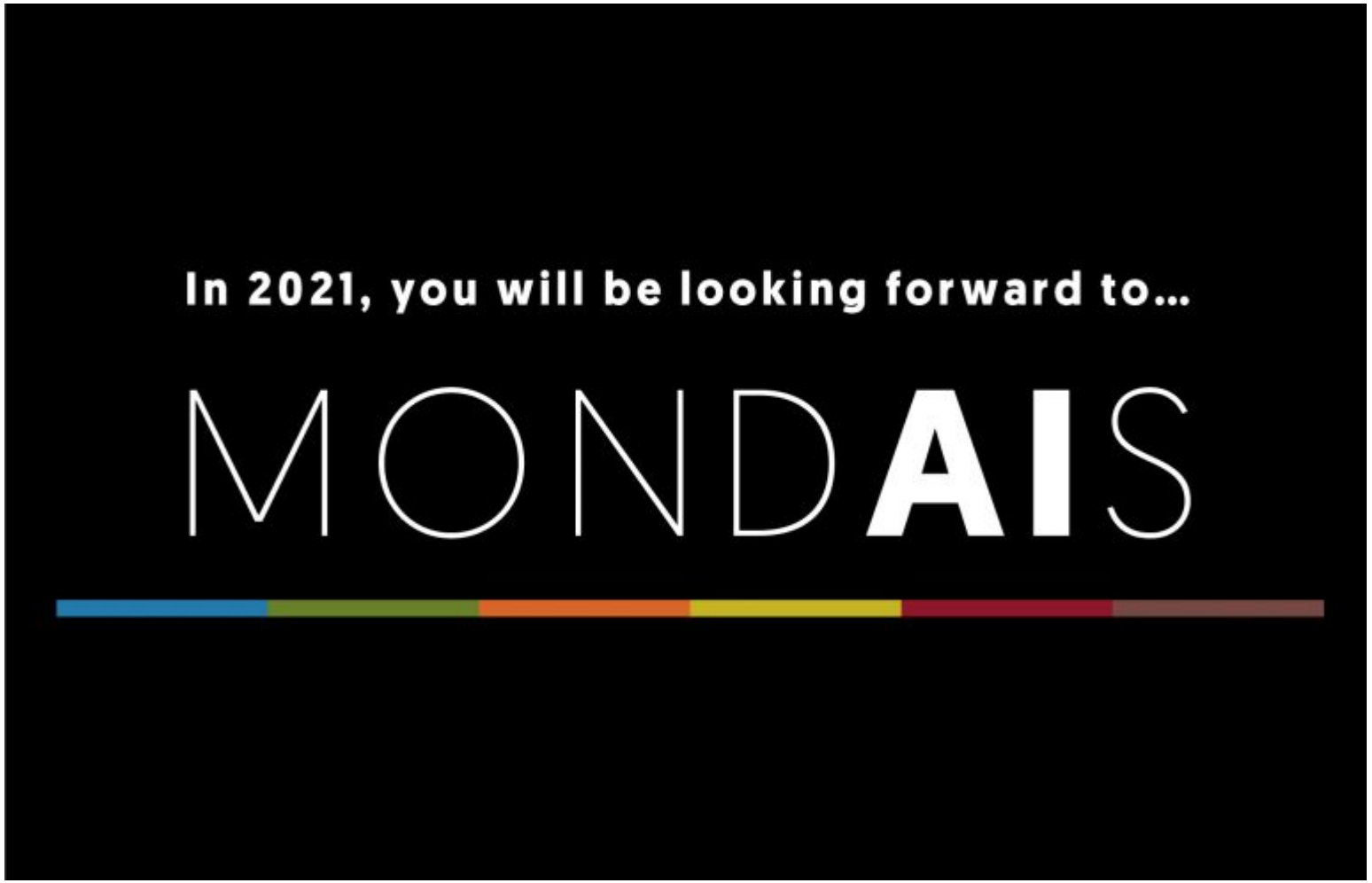
Automation should not be Human versus machine, automation should be seen as human-machine coordination as a team.

HALA, 2010

What is needed?

- Future technical improvements needs to focus on systems rather than components and on tasks rather than structures to be able to cope with complexity and deliver the expected benefits

- A participatory design or co-operative design, that actively involve all stakeholders (e.g. employees, partners, customers, citizens, end users) in the design process to help ensure the result meets their needs



Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

T.S. Eliot (1934)