Digitalisation in ATM: will it be Human?

Marc Baumgartner SESAR / EASA coordinator IFATCA

NO DRONES

IFATCA Policy is:

IFATCA is opposed to the operations of any autonomous aircraft in non-segregated airspace.

All Remotely Piloted Aircraft Systems (RPAS) operations in non- segregated airspace must be in full compliance with ICAO requirements. Whether the pilot is onboard or not shall be irrelevant for the purposes of air traffic control, therefore the same division of responsibilities and liabilities as manned aircraft shall apply.

ATCOs shall not be held liable for incidents or accidents resulting from the operations of RPAS that are not in compliance with ICAO requirements, in non-segregated airspace.

Standardized procedures, training and guidance material shall be provided before integrating RPAS into the Civil Aviation System.

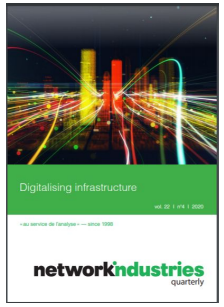
IFATCA encourages education and awareness campaigns on the use of RPAS for the general public.

IFATCA urges the development and implementation of technology to prevent airspace infringements by Unmanned Aircraft.

Contingency procedures and controller training shall be provided for the management of infringements by Unmanned Aircraft

What does IFATCA Understand when talking about digitalization?

Digitalization of infrastructure – a few basics



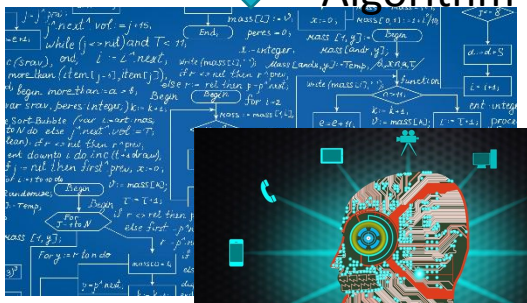
Prof. Montero in Network Industries/quarterly 12/2020 No 22
https://cadmus.eui.eu/bitstream/handle/1814/69295/NIQ%20Vol%2022%20-%20Issue%204%20-%20December%202020%20final.pdf?sequence=1

Source: IT magazine

Source: dw.com

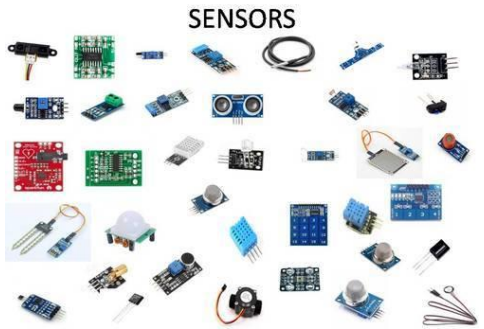
Data layer being laid over the top of reality

Algorithm



Source: IT magazine

Artificial Intelligence



Source: intenet

Mirror image of reality

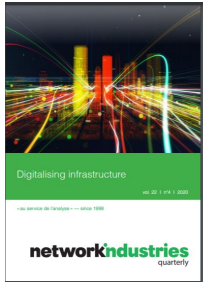
Source: intenet

Availability Underlying Infrastructure

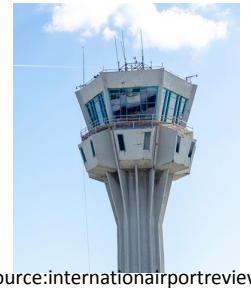
Source: satta.ch

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:internationairportreview

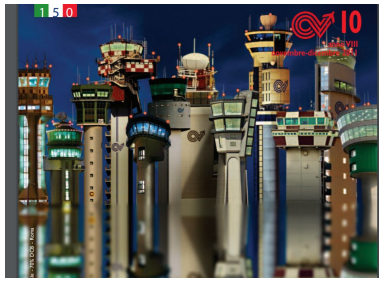
Source:DFS

Cost reduction in infrastructure maintenance

Source: skynews.ch

Source: Mozworks

Cost reduction in charging for infrastructure use

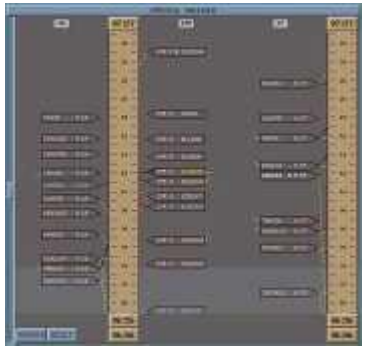


Source: enav

Source: avinor

Cost reduction in infrastructure operations

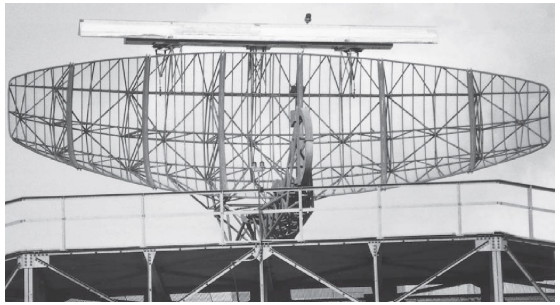
Source: imansolas



Source: Eurocontrol phare

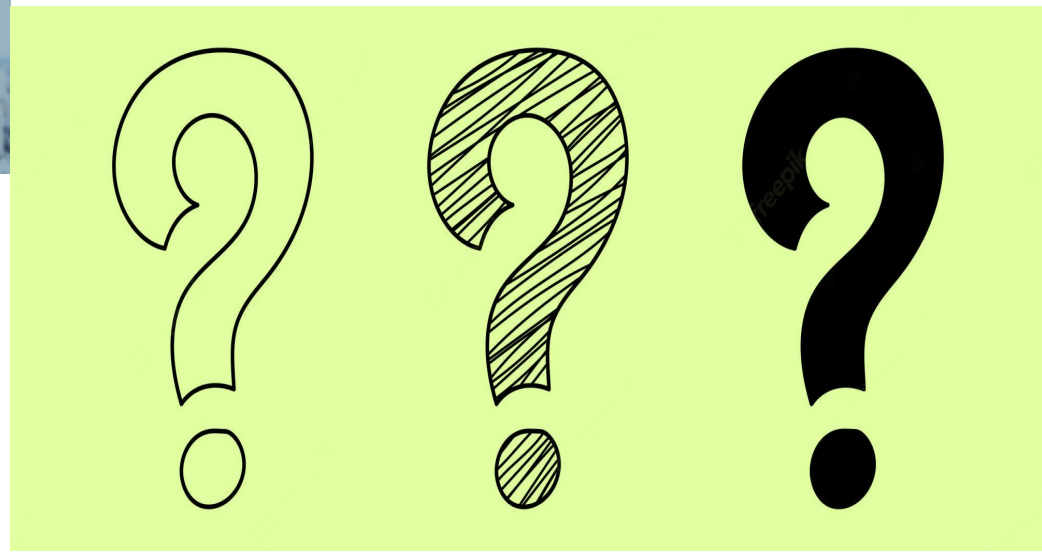
From shrimp boats to Radar

- In the late 50s early 60s **RADAR** was introduced in the **ATC.**
- Since then, it became the standard tool for Air Traffic Controllers.
- Controllers now take an extensive formal and on job training training in the fundamentals of the Radar Systems theory and data processing systems .



AI is the analogous paradigm of RADAR in our era

- The introduction of **AI/ML** can be so transformative as it was **RADAR** back in 50s.
- We don’t know yet how radical this transformation will be, but we need to influence it to the right direction.
- Right now, Controllers do not receive formal training on **AI/ML**.
- Is this something that needs to change?

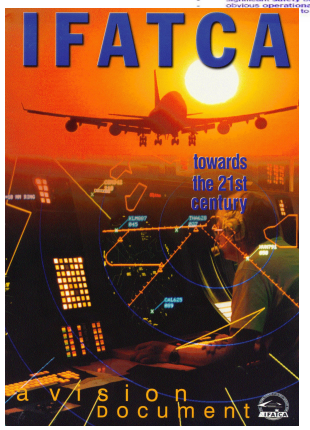


How IFATCA is addressing these new challenges

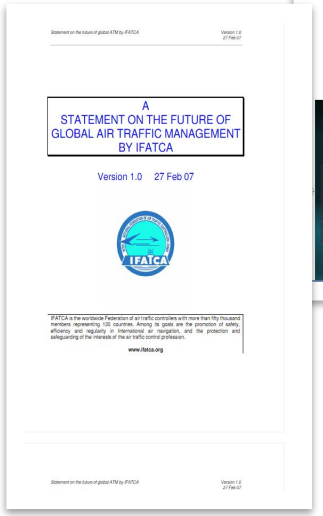

OPERATIONAL CONCEPTS Seminar
ABBAYE du VAUX de CERNAY

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
- adaptation to the controller's needs



2003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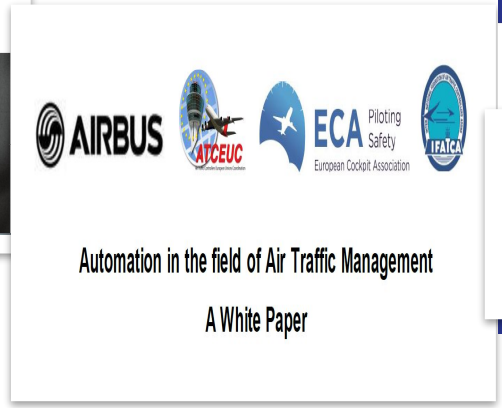
STATEMENT ON THE FUTURE OF GLOBAL AIR TRAFFIC MANAGEMENT BY IFATCA
Version 1.0 27 Feb 07

2007

2008



2015

2015

1997-98

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?

Creation of the Joint Cognitive Human Machine System Group Of IFATCA

Composed:

Nora Berzina – ATCO in Maastricht, Master in Safety Science
Gabriele Fabris – ATCO in Italy
Tom Laursen – retired ATCO Denmark, Master in Safety Science
Dr. Stathis Malakis – ATCO in Greece, PhD. In Computer Science
Dr. Anthony Smoker – retired ATCO UK, PhD. In Human Factors
Marc Baumgartner – ATCO in Switzerland, coordinator

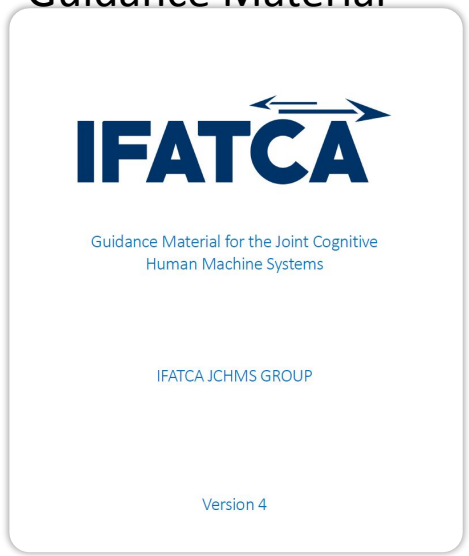
IFATCA JCHMS activity fan

Participation to SESAR ER calls

Conference Papers
Publications

Reach out to Industry

Guidance Material



Reach out to Research community

Challenges 1/3

- Extensive introduction of AI is expected to create a new ATM environment:

  ✔ more complex and tightly coupled to cope with increased traffic,

  ✔ minimize delays,

  ✔ accommodate a diverse array of autonomous aircraft,

  ✔ operate in adverse weather,

  ✔ smooth out aircraft trajectories and

  ✔ minimize environmental impact.

- EASA's projects to accommodate Extended Minimum Crew Operations (eMCOs) and and Single Pilot Operations (SiPOs), rely heavily on AI and the application of powerful Machine Learning (ML) methods.

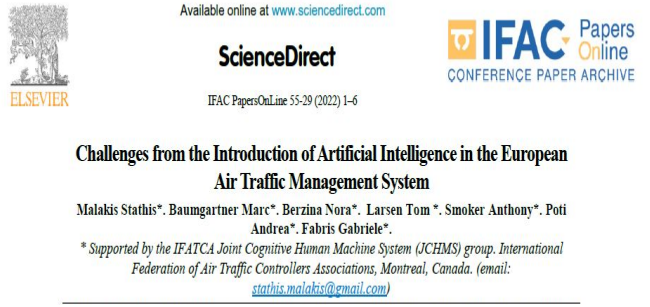
CHALLENGES 2/3

- Difficult organizational and operational trade-offs
  - Operations rooms are hectic workplaces, and in many cases, work demands exceed resources, so ATCOs have to do their best and manage their traffic by adjusting their practices to meet existing conditions.
  - Current safety methodologies cannot cope well with AI related projects especially when it comes to learning assurance (EASA, 2020, 2021).

- Transform or transfer hazards to other stakeholders
  - In many cases, risks may be transformed or transferred among ATM stakeholders since the solution of one's own concerns may create problems elsewhere. For instance, adverse weather is a safety hazard for all flight operations.

- Patterns of events that are difficult to anticipate, monitor or comprehend

  - Complex aviation systems require pilots and controllers to anticipate critical events and stay ahead of traffic so that they get prepared for new evolving situations. For this reason, the set capacity values for a specific sector are often lower than the actual capacity.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Challenges from the Introduction of Artificial Intelligence in the European Air Traffic Management System

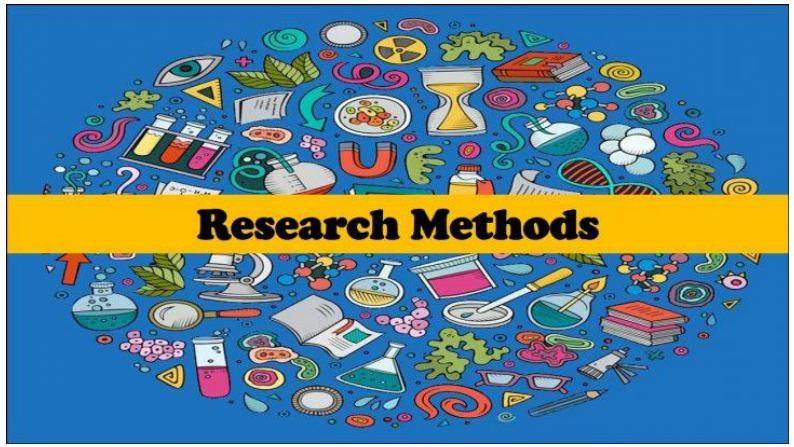
Malakis Stathis*. Baumgartner Marc*. Berzina Nora*. Larsen Tom *. Smoker Anthony*. Poti Andrea*. Fabris Gabriele*.

* *Supported by the IFATCA Joint Cognitive Human Machine System (JCHMS) group. International Federation of Air Traffic Controllers Associations, Montreal, Canada. (email: stathis.malakis@gmail.com)*

CHALLENGES 3/3

Human Machine Teaming in the ATC Operations Room: The IFATCA's perspective

- Focus on designing and delivering operator-centered technology.
- The trade-off between augmentation and assistance must be carefully balanced.
- Aim for a diverse set of operators and use-case scenarios
- Develop and utilize several technology specific and operational metrics.
- Design the technology with the capability to monitor and update the system after deployment
- Test the systems in isolation and in cooperation with the other affected systems.



CHALLENGES 3/3

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- The following three principles apply to AI specific projects:
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  - Understanding the limitations of the datasets and models used.
  - Design early the AI model to be interpretable.

CHALLENGES 3/3

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- The following three principles apply to AI specific projects:
  - Data Sets (test, training, validation) must be carefully selected, preserved, and utilized.
    - ***a) Does your data contain any mistakes?***
    - ***b) Is the data sampled in a way that represents the users?***
    - ***c) Are any features in the model redundant or unnecessary? Use the simplest model that meets the performance goals is the preferred solution.***
    - ***d) Are the data biases effectively resolved?***
  - . The list of considerations to be addressed are:
    - ***a) Hyperparameters tuning (e.g., for Neural Networks: Number of layers, number of neurons in each layer, and their connections, selection of the activation functions in each layer, learning rate).***
    - ***b) Overfitting.***
    - ***c) Avoiding data leakage between training validation and testing data sets.***
    - ***d) Removing bad data (e.g., Garbage characters or error codes).***
    - ***e) Identifying missing data.***
    - ***f) Split test vs cross validation.***
    - ***g) gLimit checks (e.g., Range limits, min. and max. values for the parameter).***
    - ***h) Consistency checks against the operating design domain (ODD).***
    - ***i) Dimensionality reduction.***
    - ***j) Feature engineering.***
    - ***k) Normalization and Standardization (scaling).***
    - ***l) Data labelling.***
    - ***m) Bias management (Bias introduced by any sampling which could be applied to the data, Bias introduced when performing data cleaning or removal of presupposed outliers, Recall bias introduced during data annotation or data labelling, Bias introduced by adversarial attack resulting in data poisoning)***
    - ***n) Capturing Singularities.***
    - ***o) Selection of the training stopping criterion(criteria) for ML models.***
    - ***p) Explainability of ML models.***

CHALLENGES 3/3

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stay tuned...
More to Come!

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Challenges from the Introduction of Artificial Intelligence in the European Air Traffic Management System

Malakis Stathis*. Baumgartner Marc*. Berzina Nora*. Larsen Tom *. Smoker Anthony*. Poti Andrea*. Fabris Gabriele*.

* *Supported by the IFATCA Joint Cognitive Human Machine System (JCHMS) group. International Federation of Air Traffic Controllers Associations, Montreal, Canada. (email: stathis.malakis@gmail.com)*

Abstract: The Air Traffic Management (ATM) system can be defined as a "Joint Cognitive System" of
miliar and unfamiliar
nd Big Data we live,
s with the pervasive
paper, we present the
of the introduction of
g paradigm. We also
elated patterns in the

trol, Air Traffic

gies not only provide capacity
and other performance
ew regulatory, safety, cognitive
d tradeoffs. Therefore, there is
e introduction of AI cautiously.
initial attempt to detect and
allenges of implementing AI, in
through the lens of Cognitive
aradigm (Hollnagel and Woods,
006).

Reducing the gap between designers and users, Why are aviation practitioners here again?

Laursen, T., Smoker, A.J., Baumgartner, M., Malakis, S. & Berzina, N. supported by the IFATCA JHMS group
International Federation of Air Traffic Controllers Associations, Montreal, Canada,
tom.laursen@ifatca.org

INTRODUCTION

Our approach to designs for human-system integration resulted in designs with reduced margins to manage and work with uncertainty and surprise within the work systems. This paper argues that technological designs often underperform compared to the promised benefits delivered. The reason for this is principally because designs have been based on a strategy where practitioners e.g., ATCOs, pilots etc, are expected to take over in abnormal conditions - the so called 'left-over' design strategy' or the (Inagaki, T, 2014, p235)). Inagaki also argues, citing Rasmussen & Goodstein, that there is a need to retain the human in the system to 'complete the design, so as to adapt to the situations that designers never anticipated' (Inagaki, 2014, p235) We argue that the need to change this philosophy of design is necessary, as Boy argues: "We cannot think of engineering a design without considering the people and the organisations that go with it" Boy argues (Boy, 2020). The operating environments of interest here, complex macro-cognitive work designs, are what Boy refers to as socio-cognitive systems (Boy, 2020) and are confronted with the challenge of digitisation and integration of artificial intelligence.

Uncertainty and surprises will always be an element of complex systems,

Complexity research (Flach, 2014; Heylighen, Cilliers & Gershenson 2007, Cilliers, 2000) and the study of chaotic dynamics have demonstrated that uncertainty and surprise are fundamental aspects of the world around us (Eisenberg, Seager, Alderson, 2019; Lanir, 1983). Instead of an ordered system, such as machines, the aviation system is a complex system whose properties emerge from nonlinear interactions of numerous different agents. These interactions, and the

SINGLE EUROPEAN SKY AND RESILIENCE IN ATM – CAN THIS BE A 'WIN-WIN' FOR THE AVIATION INDUSTRY? – THE IFATCA INPUT

IFATCA Joint Cognitive Human Machine Systems Team[1]

Human Machine Teaming in the ATC Operations Room: The IFATCA's perspective

Stathis Malakis, Marc Baumgartner, Nora Berzina, Tom Laursen, Anthony Smoker, Andrea Poti, Gabriele Fabris
IFATCA Joint Cognitive Human Machine System (JCHMS) group
International Federation of Air Traffic Controllers Associations - IFATCA
Montreal, Canada

Abstract— **Changes in the Air Traffic Management (ATM) domain are of permanent nature and challenges of research, development and transition to introduce these changes are a daily life for Air Navigation Service Providers (ANSPs) and their Staff. Be it Air Traffic Controllers, Technicians, Engineers, managers, and Decision makers. Automation is nothing new in the ATM system. The so-called New Technologies leading digitalization, including Artificial Intelligence (AI) and Machine learning (ML) are finding their ways into the ATM working environment. Whereas lot of expectation is linked to a so-called technology hype introduction of new technology will have to follow the path of introducing new technological component into a running ATM system. This paper presents the results of an initial attempt to design a Human Machine Teaming (HMT) guide that was written to assist Air Traffic Controllers, Operational Supervisors, Flow Controllers and Flight Information Officers integrate technology in the various forms of new intelligent, autonomous systems, automation and AI/ML that works in partnership with the human operator in the operations rooms. In our approach Technology is collective noun meaning variously intelligent systems, automation, autonomous systems, AI/ML systems and digital cognitive assistants. We propose a set of generic principles and an iterative process of four stages before fielding a technology system in the OPS rooms based on Joint Cognitive Human Machine Systems (JCHMS). We propose a set of nine principles. The first six apply to any technology system while the last three apply to AI/ML systems accompanied by a four-stage process based on pragmatic based approach based on the tenets of Cognitive Systems Engineering.**

Keywords-Air Traffic Management, Human Machine Teaming, Automation, Joint Cognitive Systems, Digitalization, Artificial Intelligence, Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) both in the air and the in the ground components. It is ubiquitous that the use of AI is spreading rapidly in every industry with aviation and ATM making no exception.

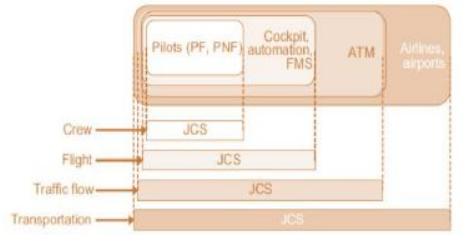

Figure 1. Human The traffic flow Joint Cognitive System (Hollnagel, 2007).

However, innovative technologies not only provide capacity enhancement opportunities and other performance improvements but also raise new regulatory, safety, cognitive and operational challenges, and tradeoffs [3]. Therefore, there is an urgent need to examine the introduction of AI cautiously and through the lens of an established research paradigm. Technology is made by humans for humans [3]. All technology that exists is made by humans. When the reliability of technology is compared with the reliability of the e.g., the human operator it is the reliability of the design and the production of the technology that is compared with the human operator [4]. Design and production of technology is done by humans, which means that talking about automation or AI/ML taking over the

IFATCA

Guidance Material for the Joint Cognitive Human Machine Systems

IFATCA JCHMS GROUP

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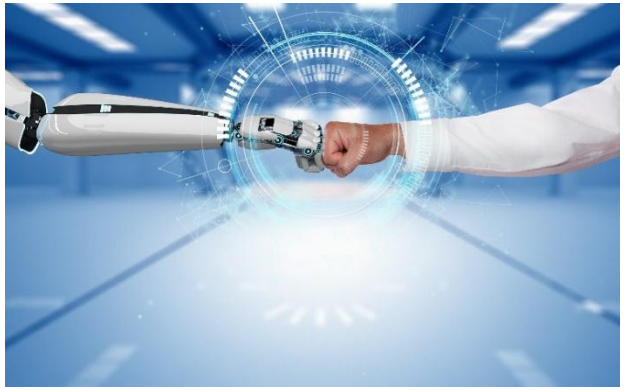
Digitalisation in ATM: will it be Human?



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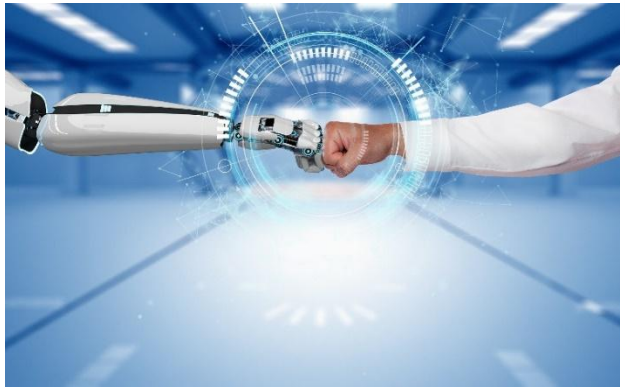
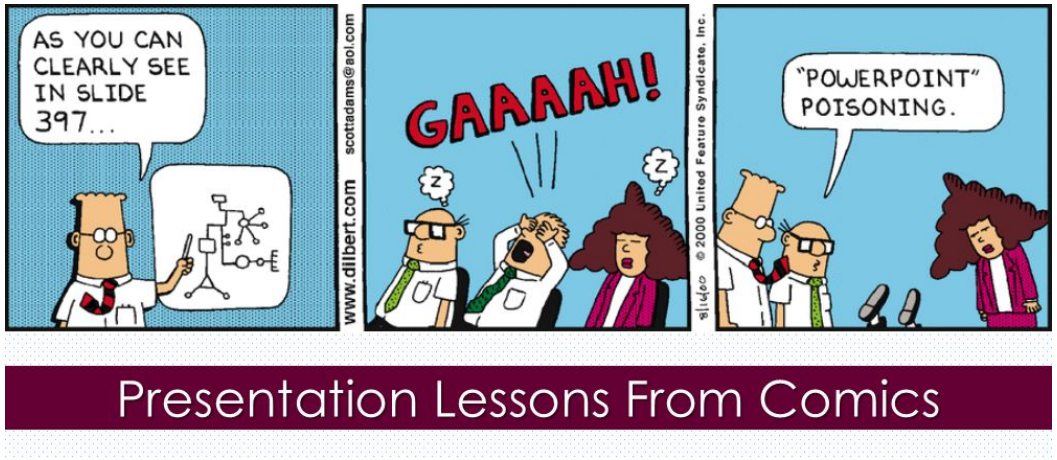
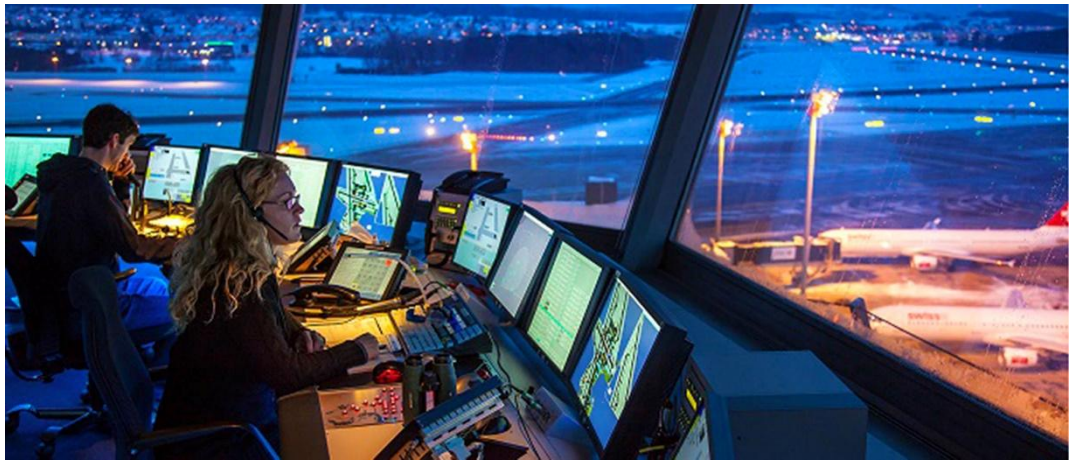


Presentation Lessons From Comics

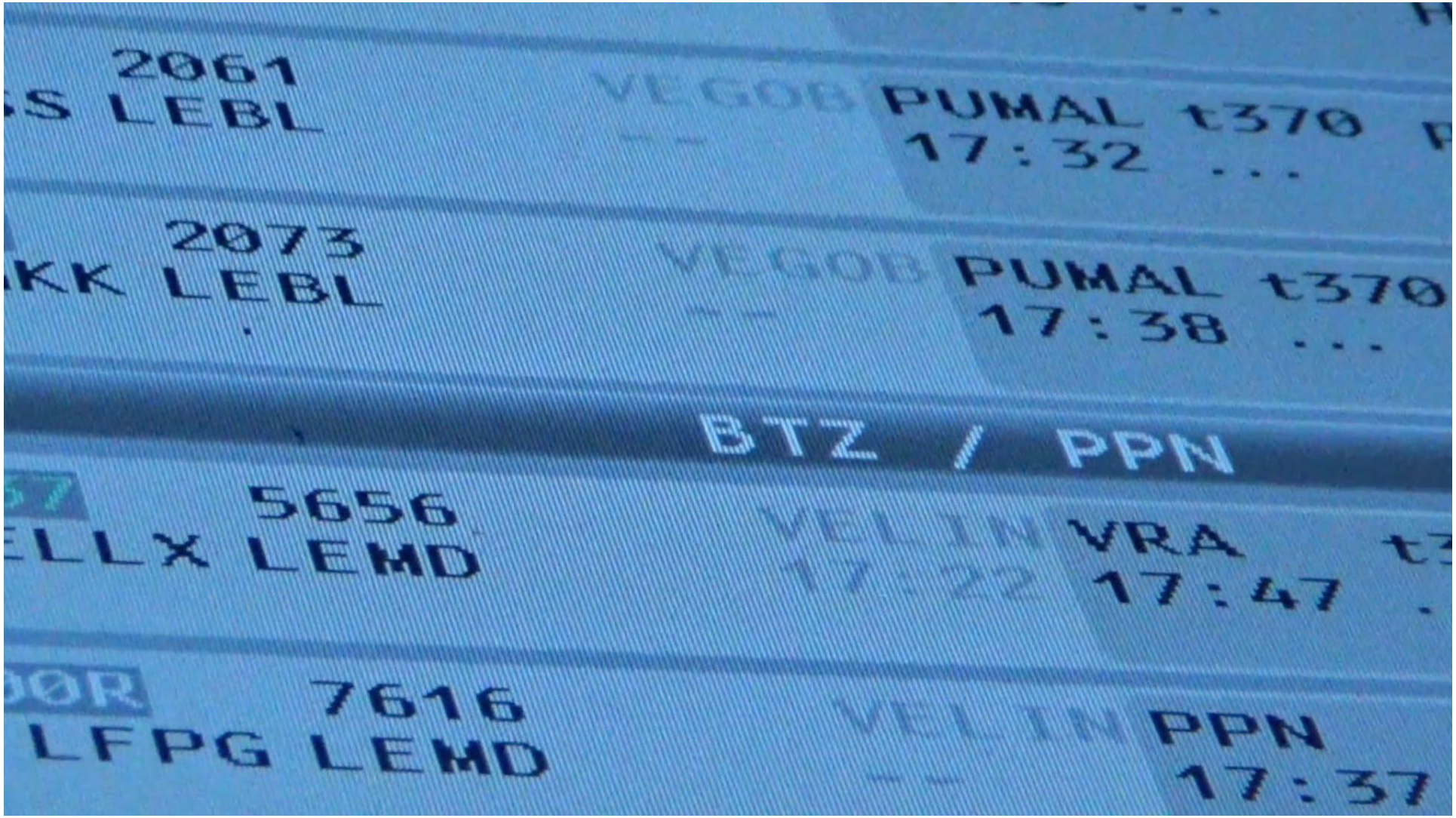
Thank you





Sesar.coord@ifatca.org

Reserve slides



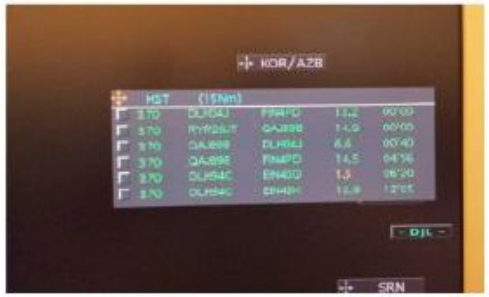
House keeping in ATM?

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.

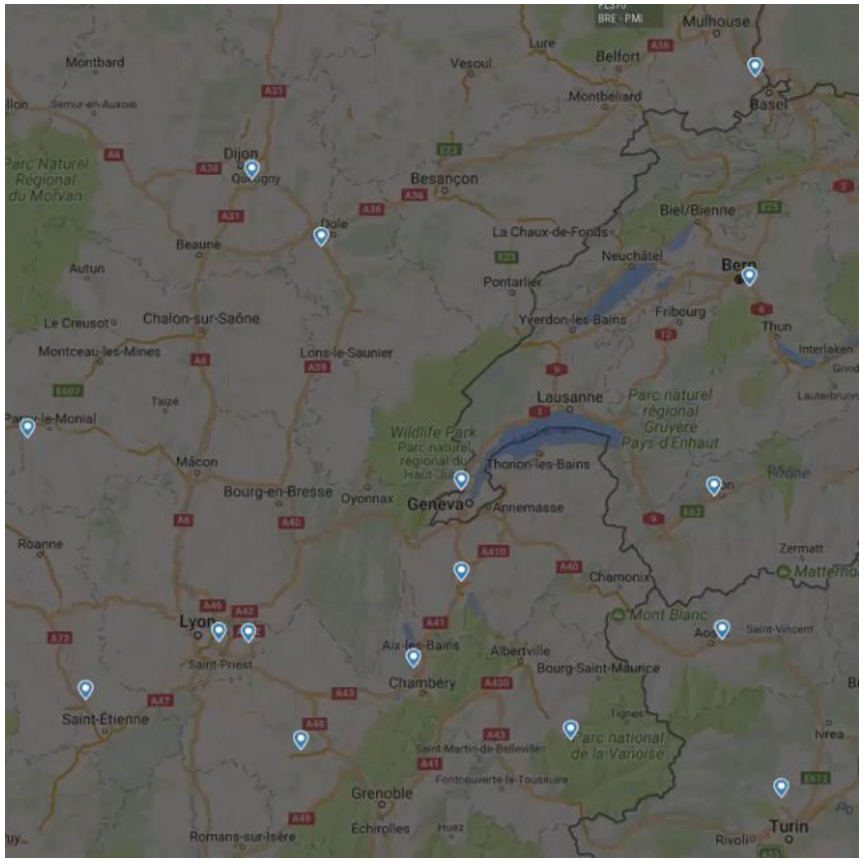
www.ifatca.org



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!

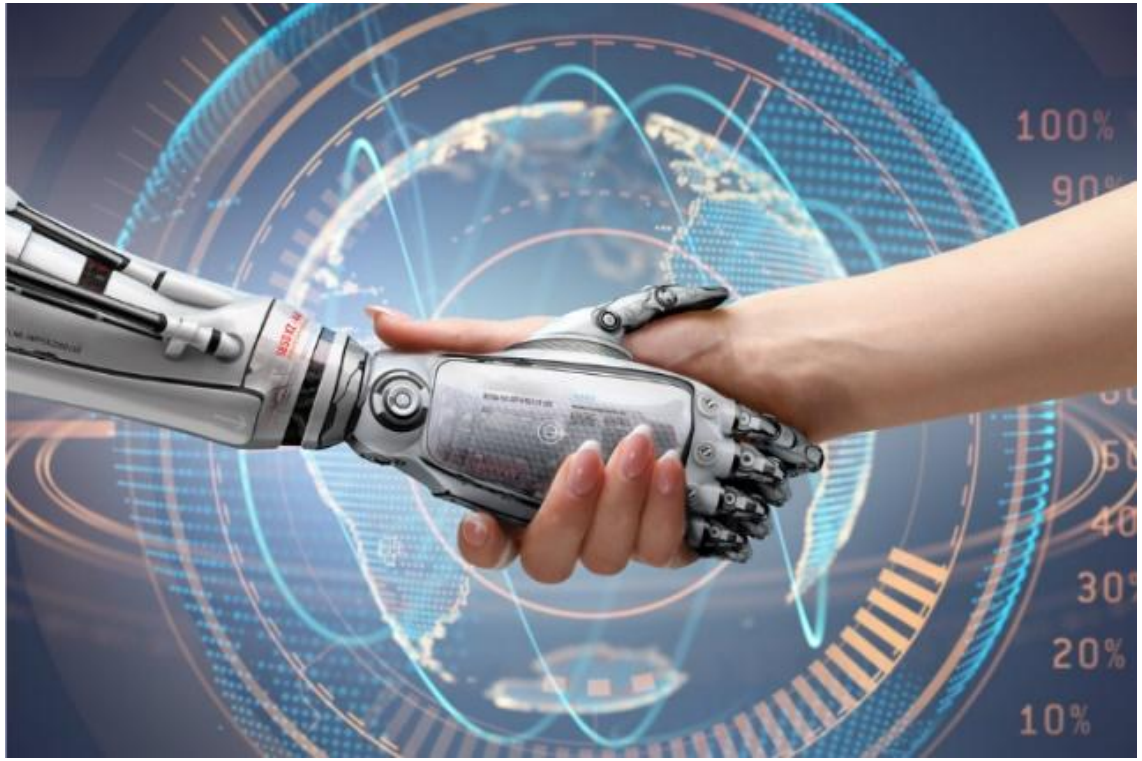
AI for safety-critical systems



Same level horizontal separation

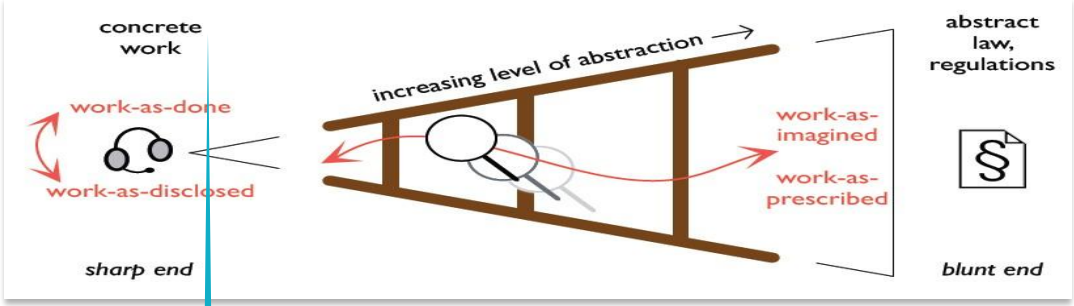
Source: X.Comte

- We argue that we need to move towards designing a socio-cognitive system.
- This is proposed as a way forward to reduce the distance between practitioners and designers so that designs incorporate joint activity and supports common ground.



Design for complex socio-technical systems, can be seen as an exercise in conflicting value systems:

- Design values with a fundamental commitment to humanistic principles.
- Managerial values.



Source: Steve Shorrock , Eurocontrol

Reduce distance between practitioners and designers

Source: HALA 2010

Embrace

Source:inspiringcommunities.org.nz

Complexity

Source:airlineperformance

Uncertainties

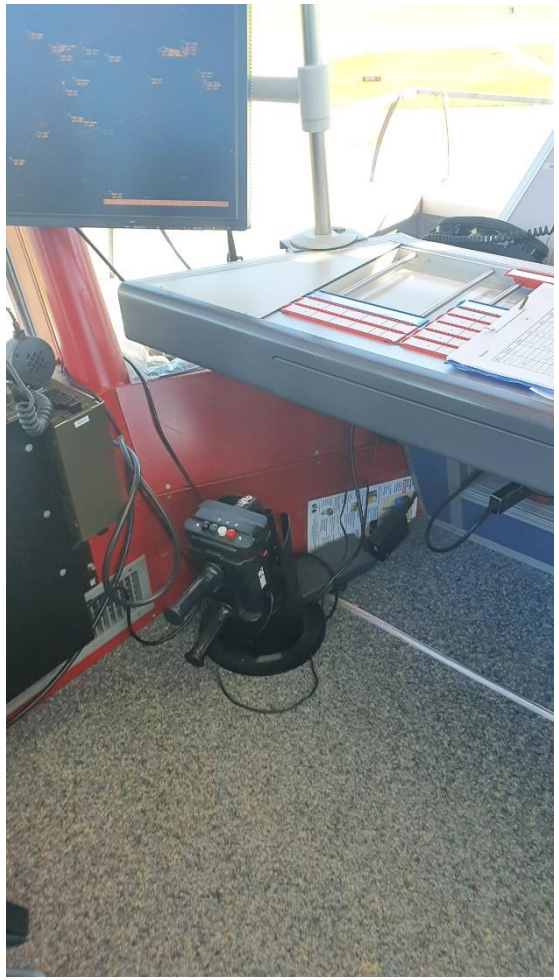
Source:worldpress bush warriors

Surprises

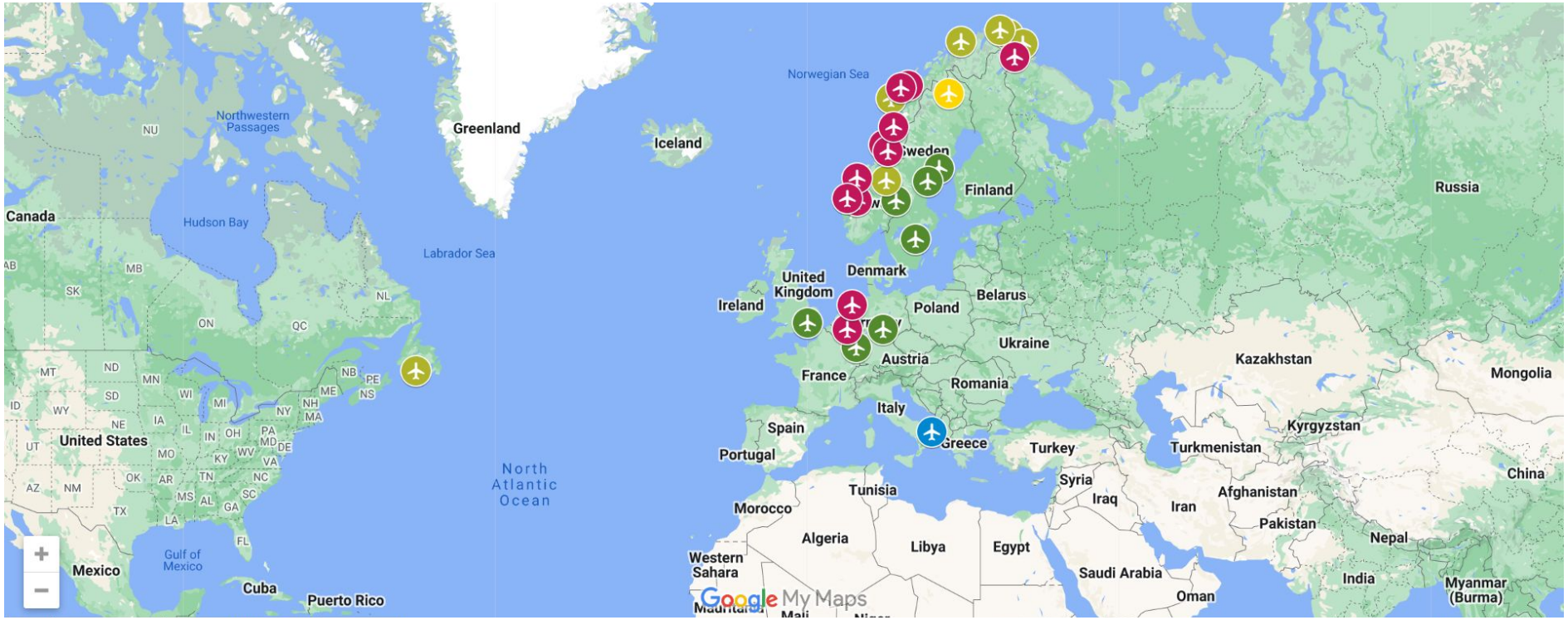
Instead
Versus

Elimination

What is next?

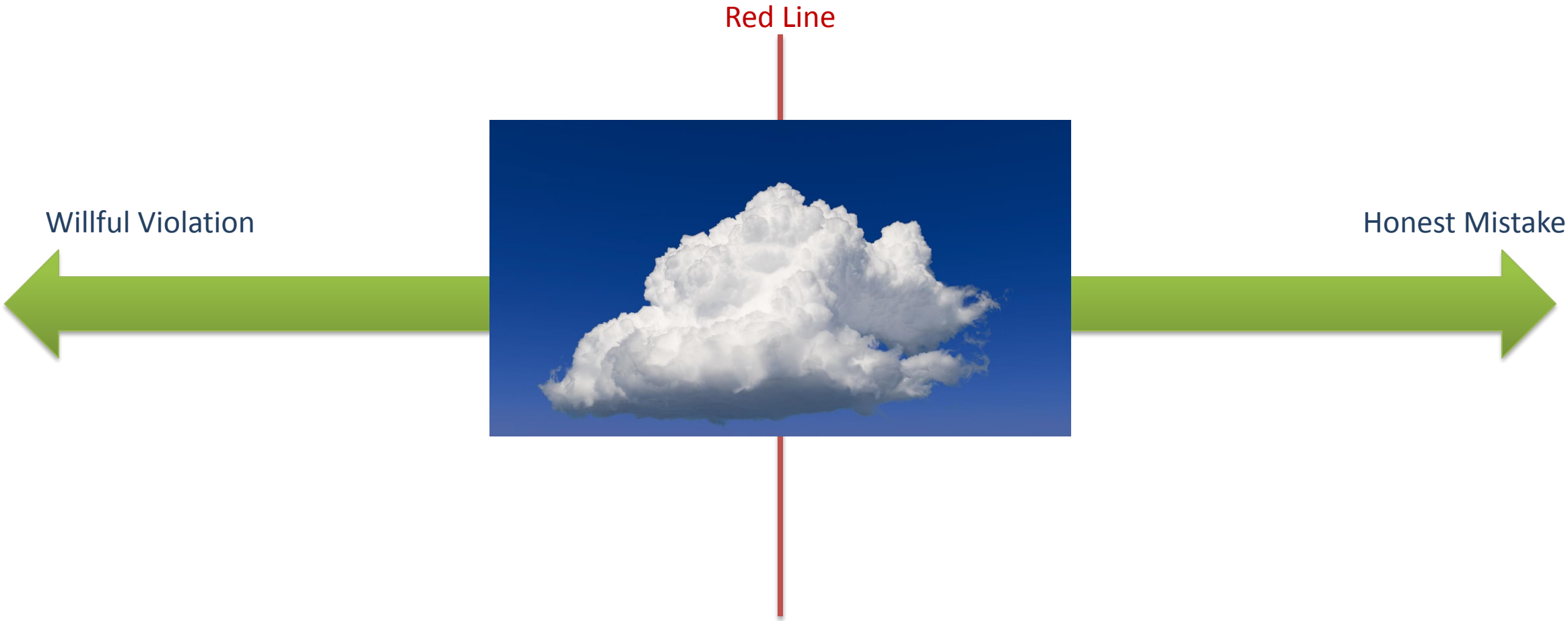


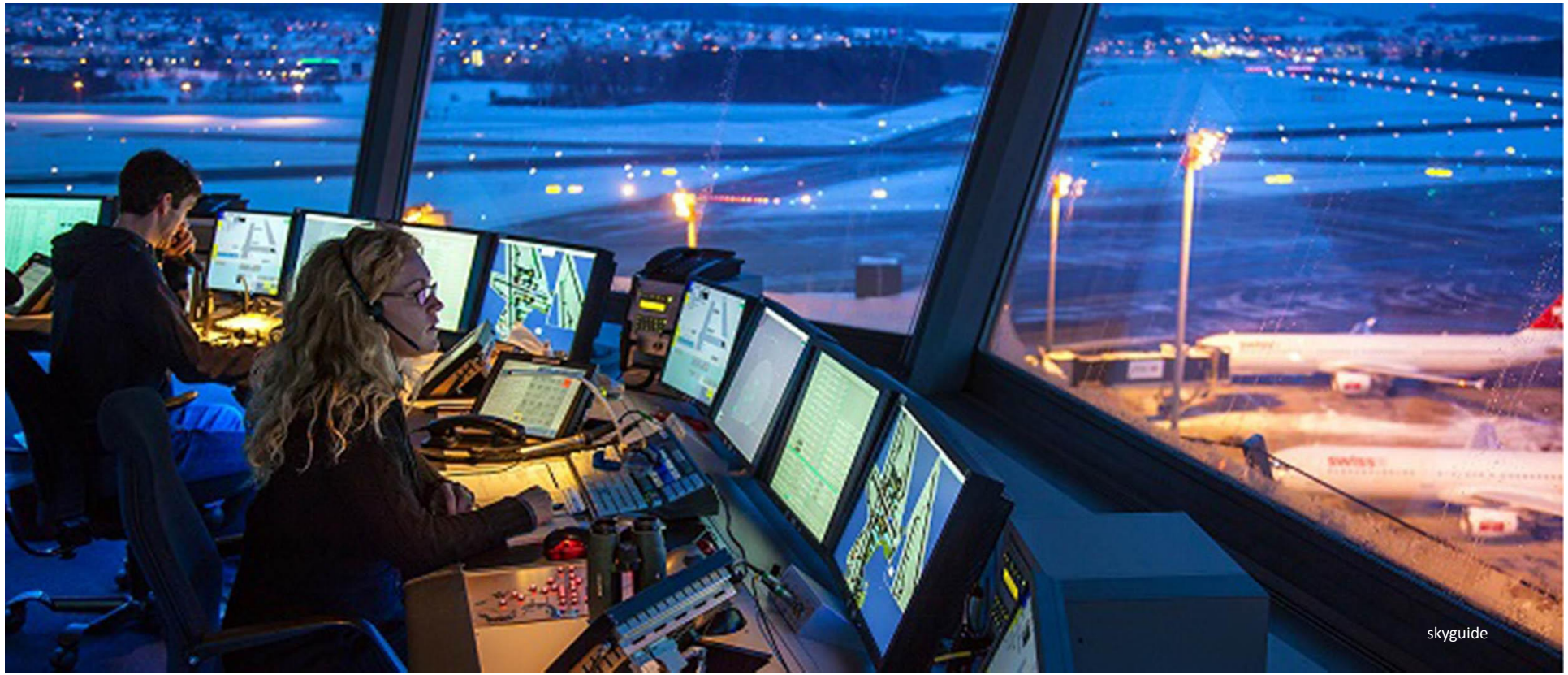
Remotely Operated Airports - Google My Maps



AI and Just Culture

- Without AI/ML it is difficult but possible to draw the red line
- The introduction of **AI/ML** **in essence clouds** the drawing of red line.
- We need to redefine just culture in the era of digitalization.





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