RPAS and AI in Aviation

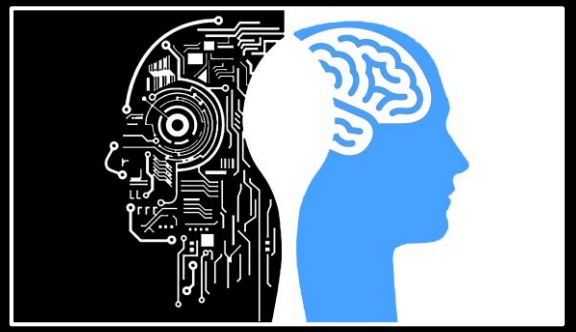
SESAR-ER4-01-2019

PROJECT NR: 894238

ARTIMATION

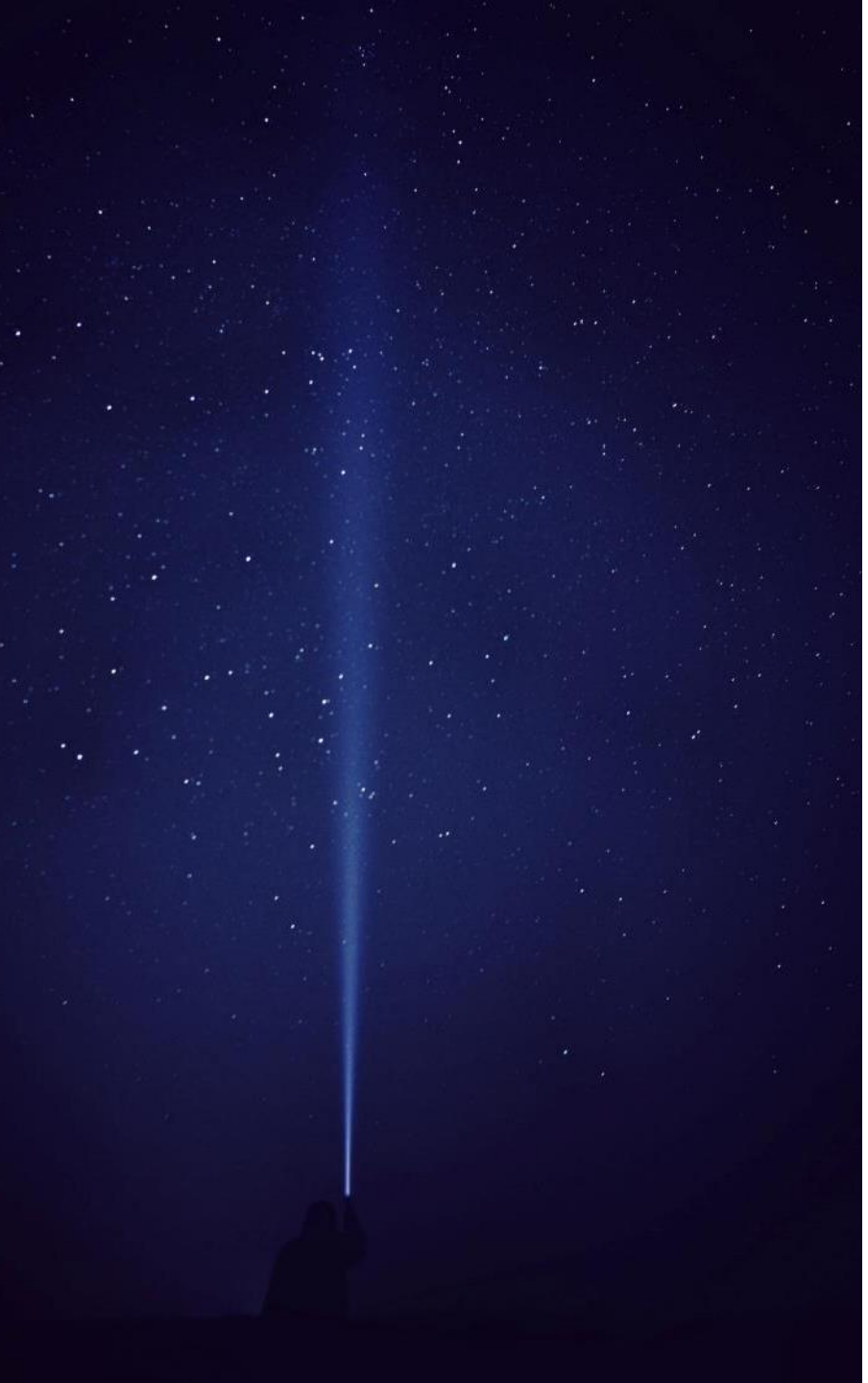
Transparent ARTIficial Intelligence and AutoMATION to Air Traffic Management Systems

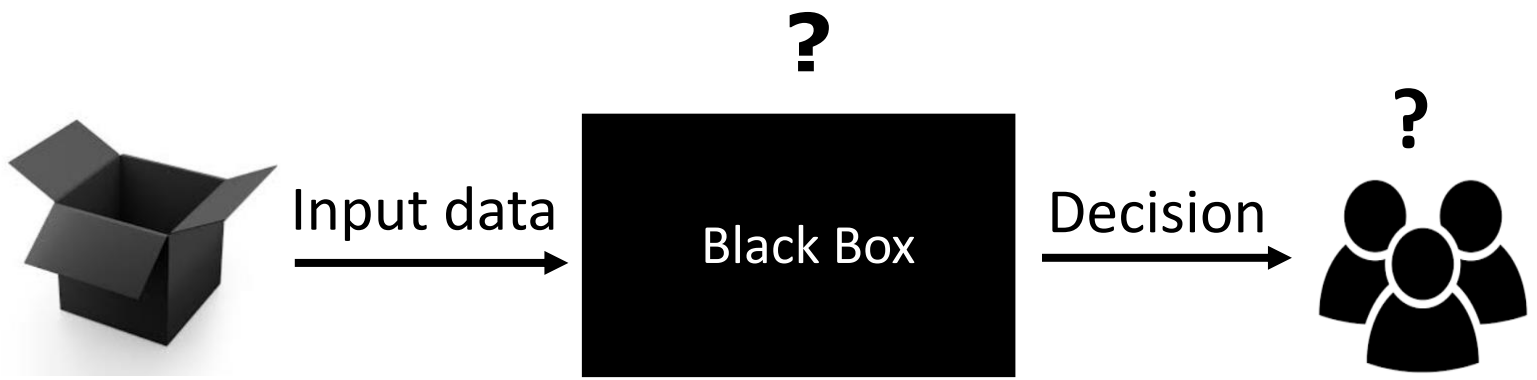
4th November 2022

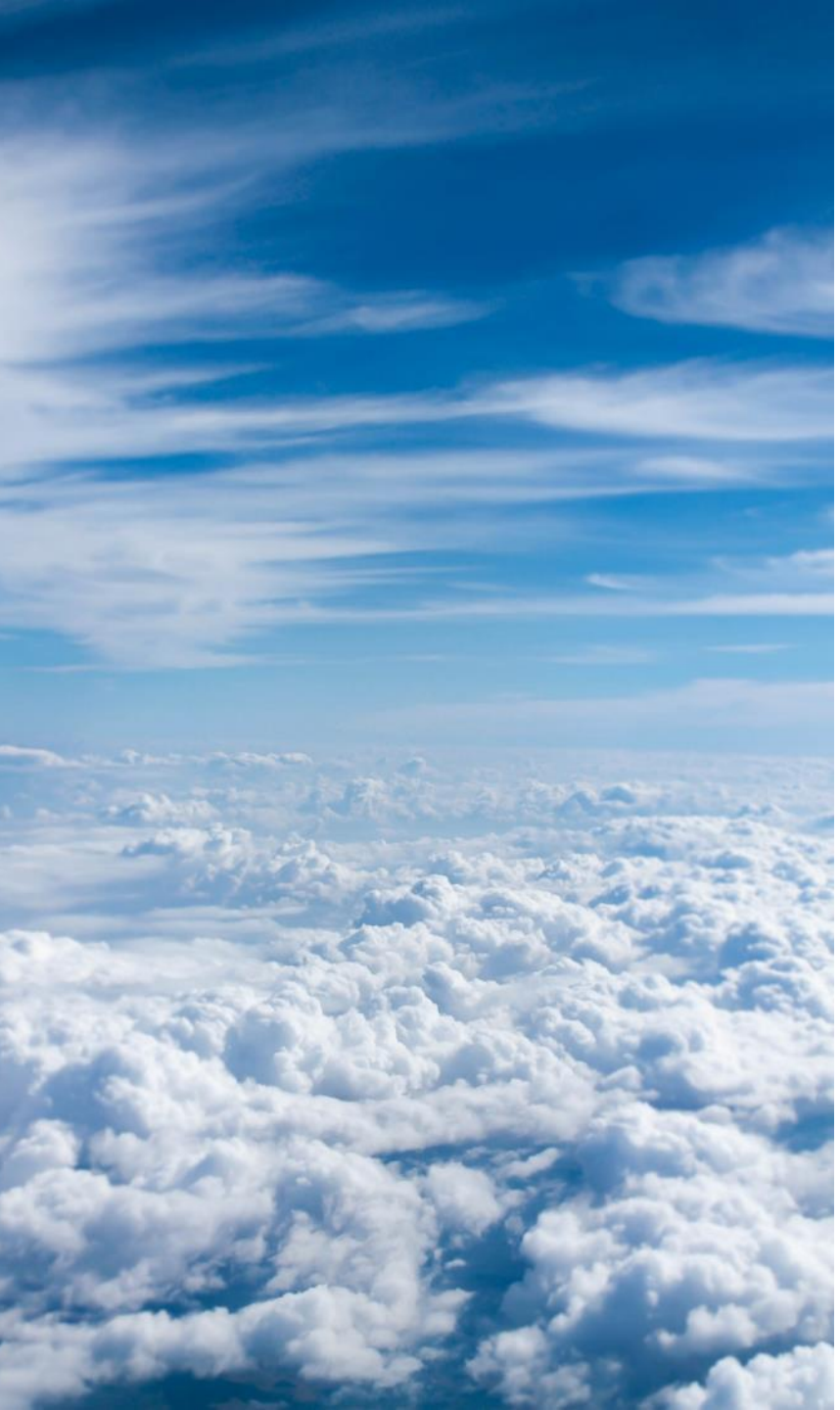


Toward

Automatization Paradigm ?




?
Input data
Black Box
Decision
?

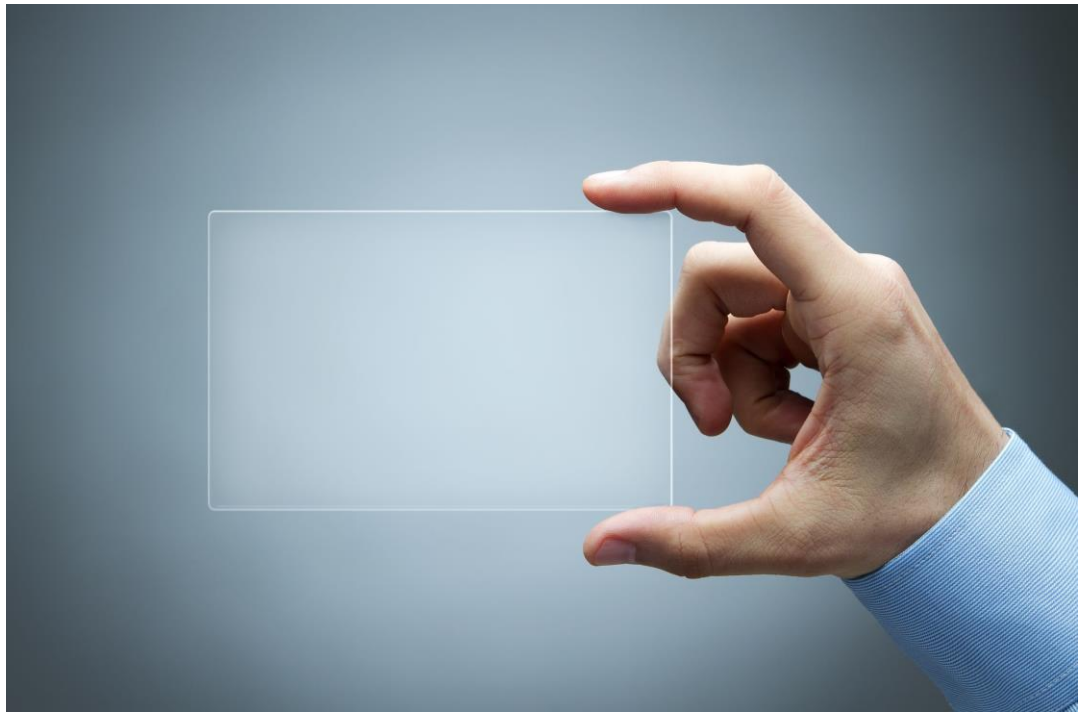


Input data

Grey Box

Decision

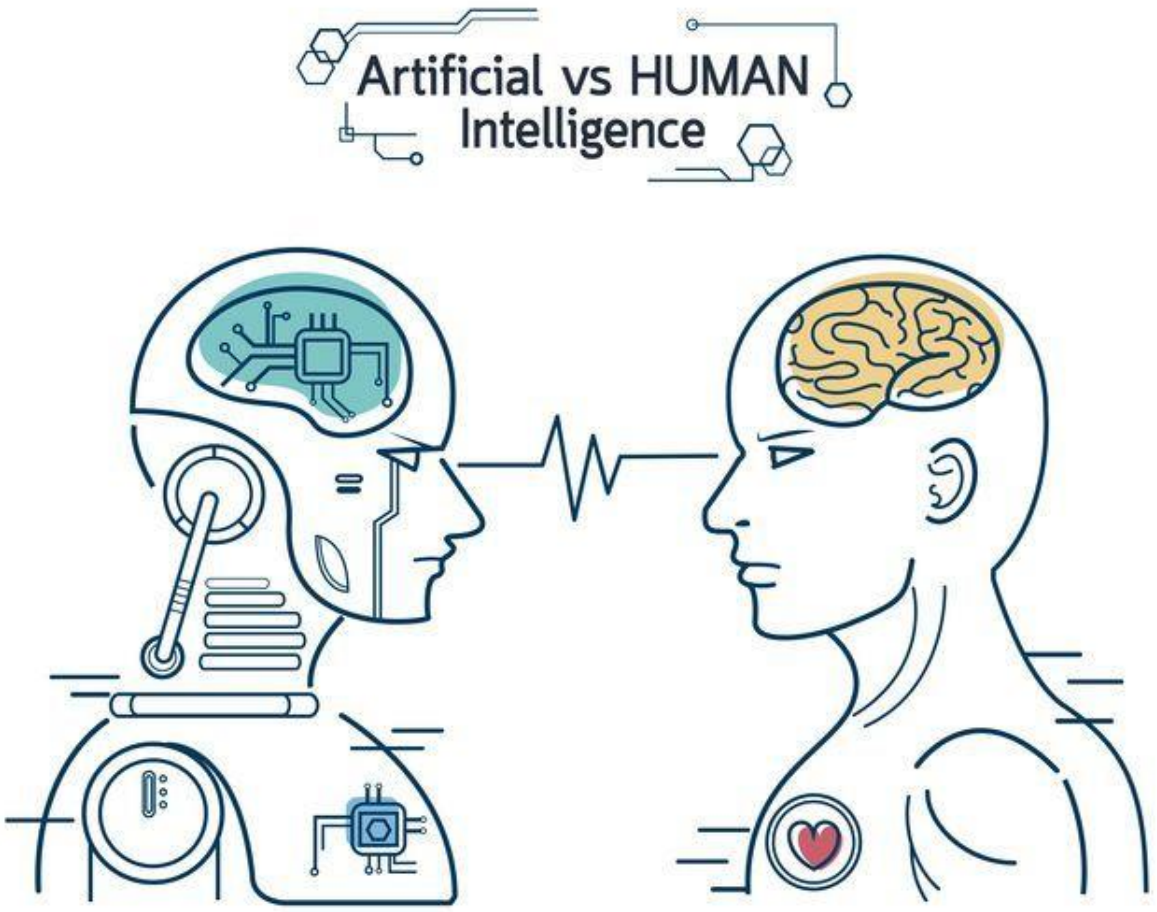
Explanation

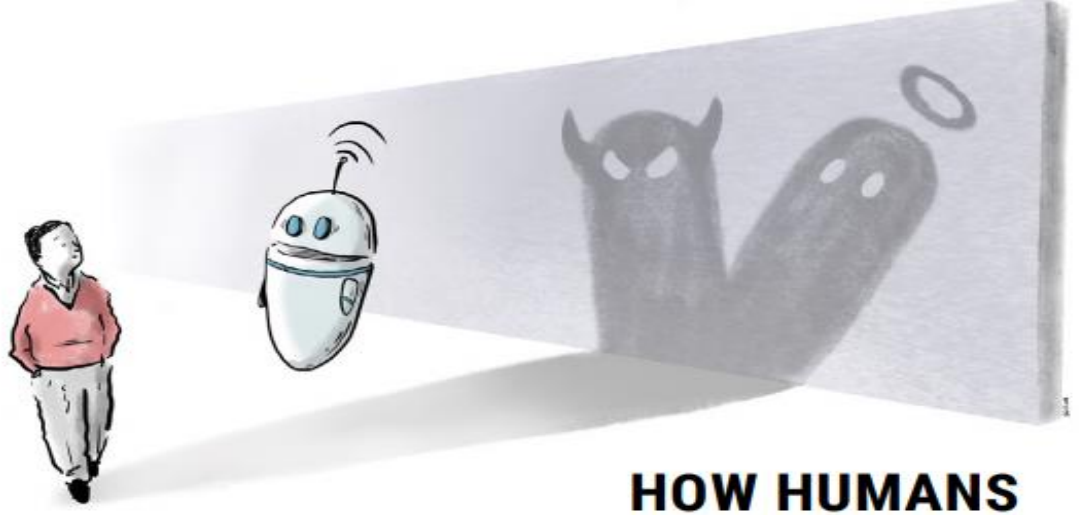


Sometimes, the rationale behind the decision is more important than the decision itself

How to open black boxes?

The key to supporting this task is not only to **visualize data**, but also to allow users to **interact with it**

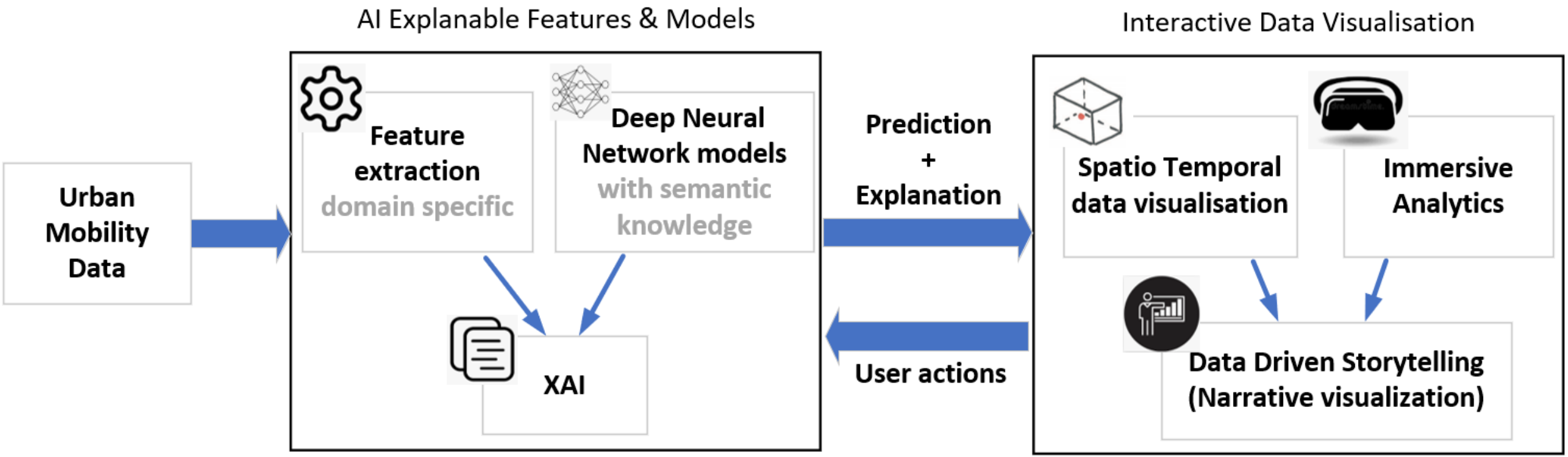




HOW HUMANS JUDGE MACHINES

Cesar A. Hidalgo, Diana Orghian, Jordi Albo Canals, Filipa De Almeida. How Humans Judge Machines Relié – 2 février 2021.The MIT Press

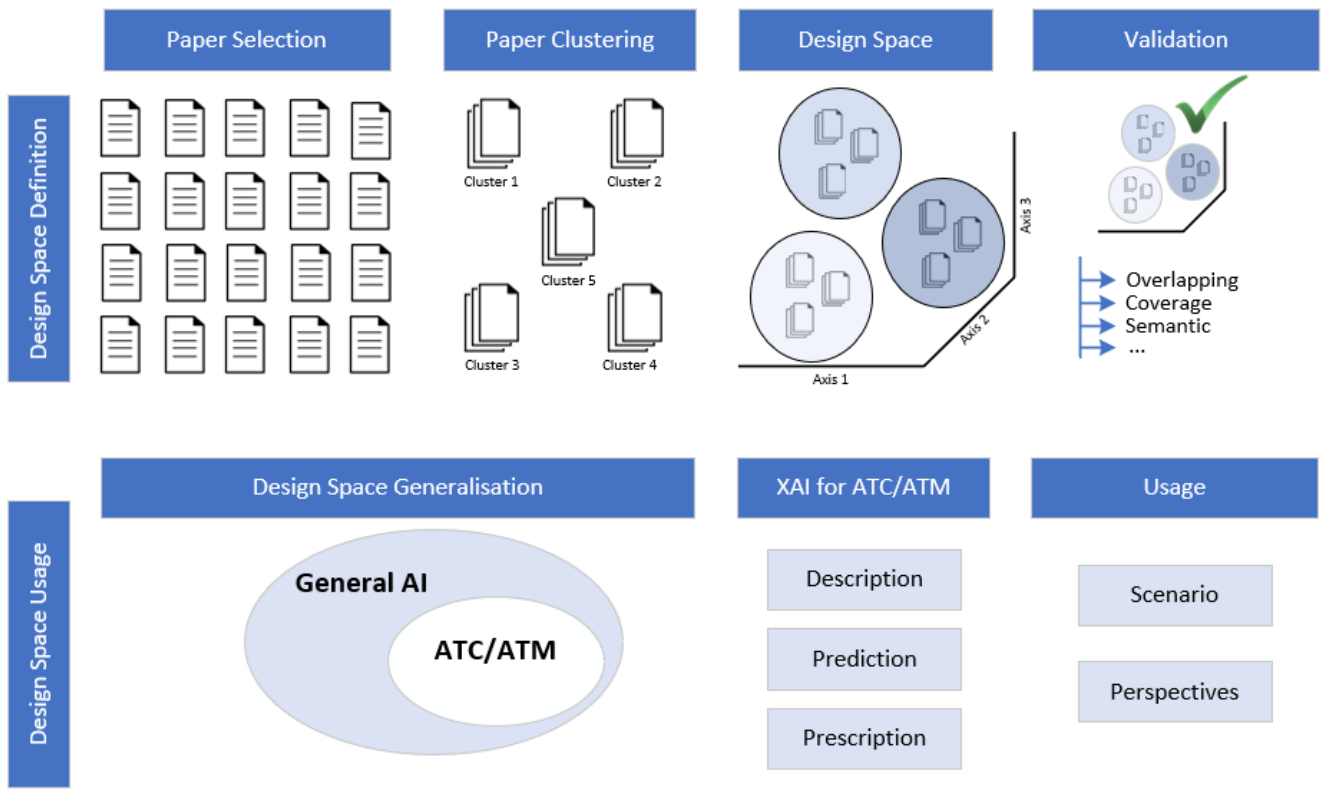
https://www.judgingmachines.com/

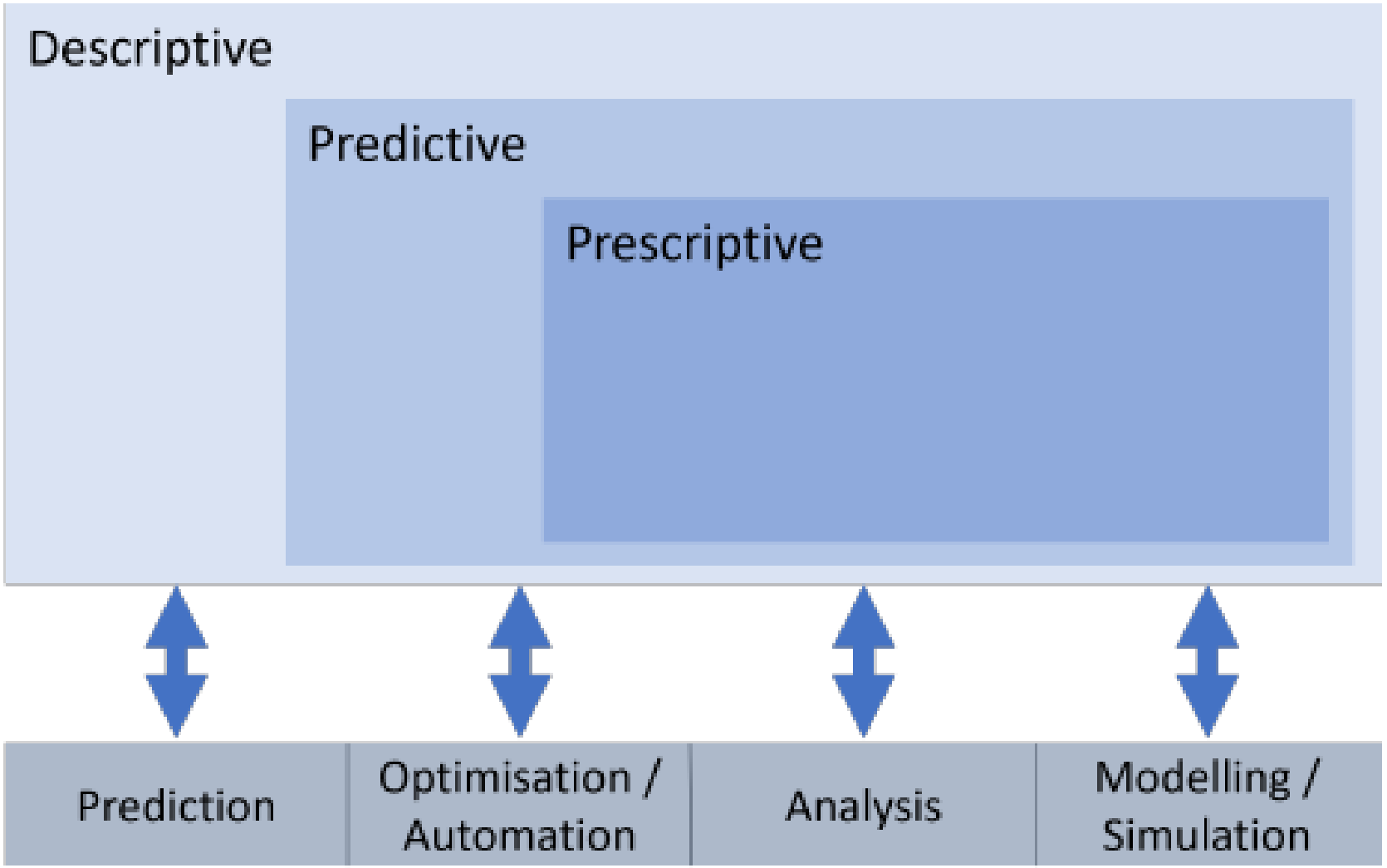

AI Explanable Features & Models
Interactive Data Visualisation
Urban Mobility Data
Feature extraction
domain specific
Deep Neural Network models
with semantic knowledge
XAI
Prediction + Explanation
User actions
Spatio Temporal data visualisation
Immersive Analytics
Data Driven Storytelling (Narrative visualization)

Systematic Review

A Survey on Artificial Intelligence (AI) and eXplainable AI in Air Traffic Management: Current Trends and Development with Future Research Trajectory

Augustin Degas [1,*], Mir Riyanul Islam [2,*], Christophe Hurter [1], Shaibal Barua [2], Hamidur Rahman [2], Minesh Poudel [1], Daniele Ruscio [3], Mobyen Uddin Ahmed [2], Shahina Begum [2], Md Aquif Rahman [2], Stefano Bonelli [3], Giulia Cartocci [4], Gianluca Di Flumeri [4], Gianluca Borghini [4], Fabio Babiloni [4] and Pietro Aricó [4]



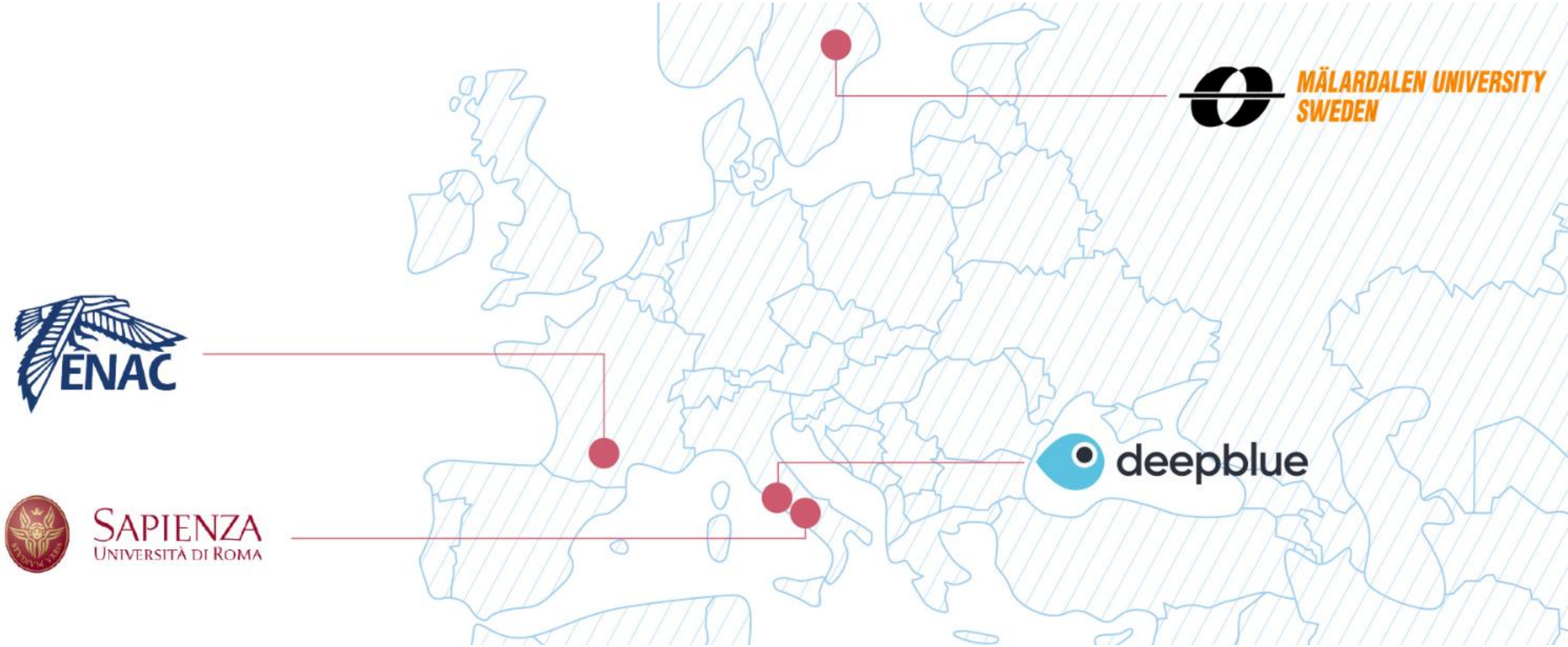


Degas, A.; Islam, M.R.; Hurter, C.; Barua, S.; Rahman, H.; Poudel, M.; Ruscio, D.; Ahmed, M.U.; Begum, S.; Rahman, M.A.; Bonelli, S.; Cartocci, G.; Di Flumeri, G.; Borghini, G.; Babiloni, F.; Aricó, P. **A Survey on Artificial Intelligence (AI) and eXplainable AI in Air Traffic Management: Current Trends and Development with Future Research Trajectory**. *Appl. Sci.* **2022**, *12*, 1295. https://doi.org/10.3390/app12031295

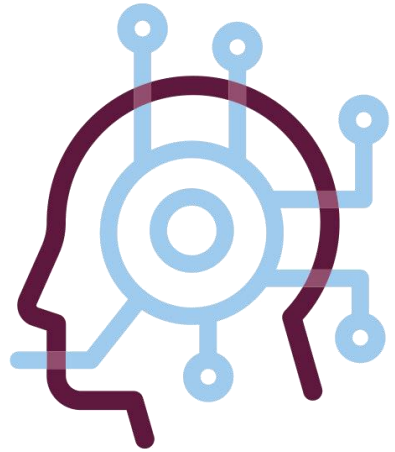
ARTIMATION

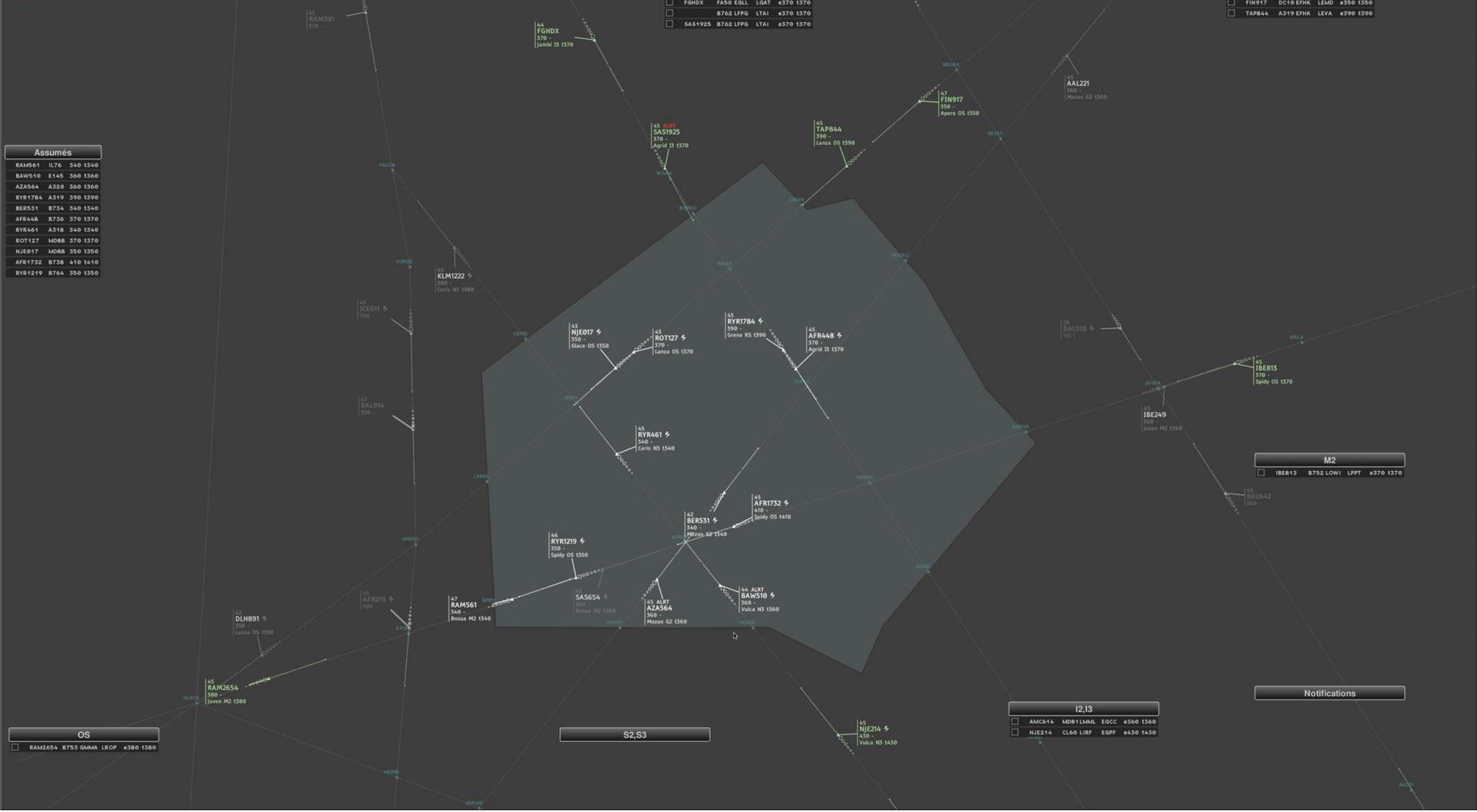
https://www.artimation.eu/

Transparent Artificial intelligence and Automation to Air Traffic Management Systems


MÄLARDALEN UNIVERSITY
SWEDEN
ENAC
deepblue
SAPIENZA
UNIVERSITÀ DI ROMA

Conflict Detection and Resolution visualisation

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RAM561 IL76 340 t340
BAW510 E145 360 t360
AZA564 A320 360 t360
RYR1784 A319 390 t390
BER531 B734 340 t340
AFR448 B736 370 t370
RYR461 A318 340 t340
ROT127 MD88 370 t370
NJE017 MD88 350 t350
AFR1732 B738 410 t410
RYR1219 B764 350 t350
FGHDX FA50 EGLL LGAT e370 t370
B762 LFPG LTAI e370 t370
SAS1925 B762 LFPG LTAI e370 t370
FIN917 DC10 EFHK LEMD e350 t350
TAP844 A319 EFHK LEVA e390 t390
RAM391
FGHDX
Jambi I3 t370
SAS1925
Agrid I3 t370
TAP844
Lanza OS t390
FIN917
Apero OS t350
AAL221
Mozao G2 t360
KLM1222
Ceris N3 t380
ICE611
DAL518
NJE017
Glace OS t350
ROT127
Lanza OS t370
RYR1784
Grena R5 t390
AFR448
Agrid I3 t370
BAL914
RYR461
Ceris N3 t340
IBE813
Spidy OS t370
IBE249
Juven M2 t360
BAL642
AFR1732
Spidy OS t410
BER531
Mozao G2 t340
RYR1219
Spidy OS t350
SAS654
Bosua M2 t360
RAM561
Bosua M2 t340
AZA564
Mozao G2 t360
BAW510
Vulca N3 t360
AFR219
DLH891
Lanza OS t350
RAM2654
Juven M2 t380
NJE214
Vulca N3 t430
M2
IBE813 B752 LOWI LPPT e370 t370
OS
RAM2654 B753 GMMA LROP e380 t380
S2,S3
I2,I3
AMC614 MD81 LMML EGCC e360 t360
NJE214 CL60 LIRF EGPF e430 t430
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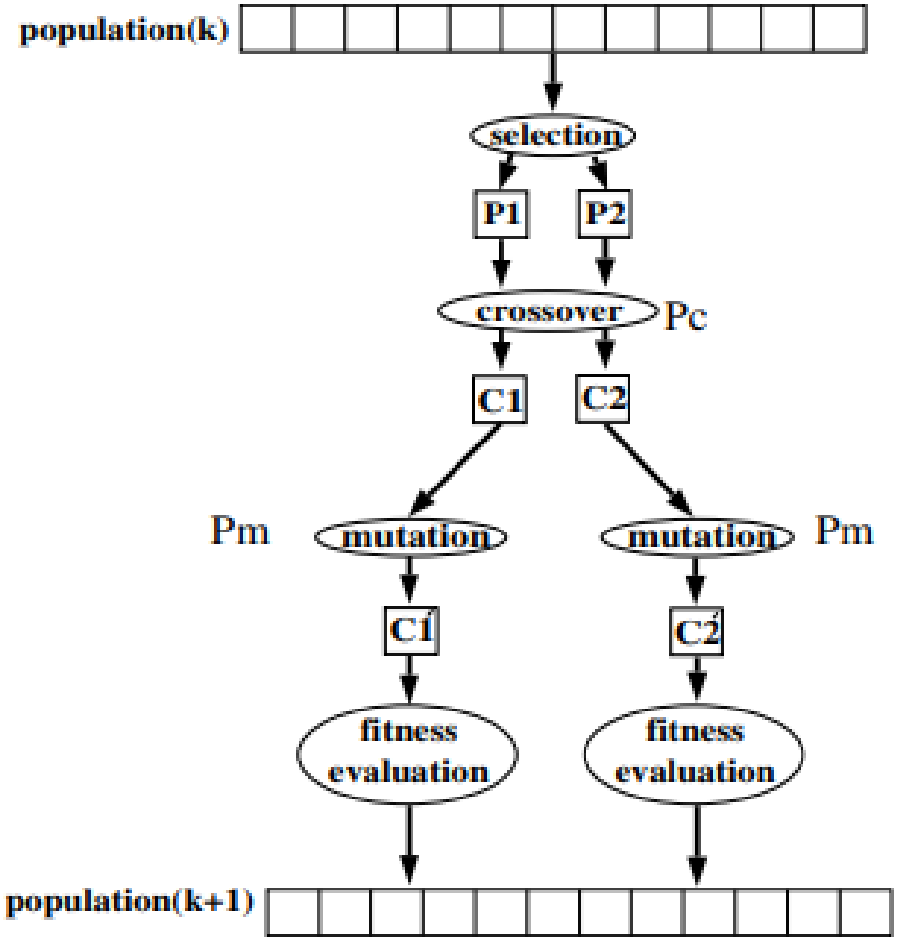
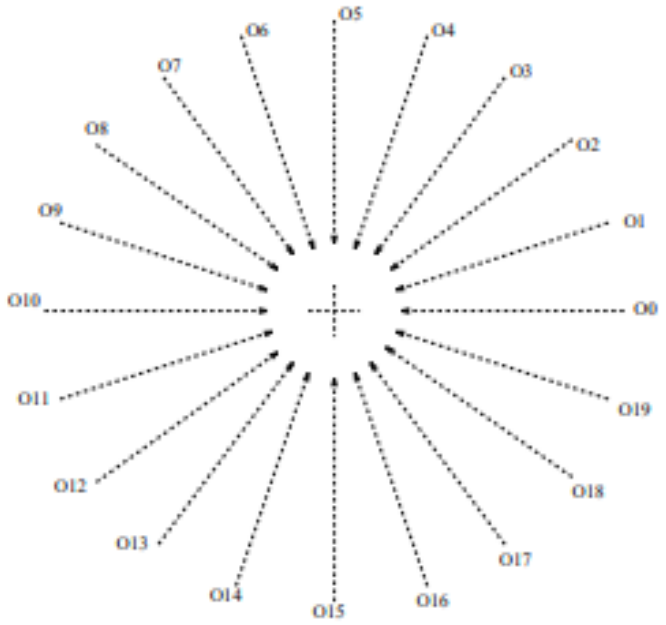
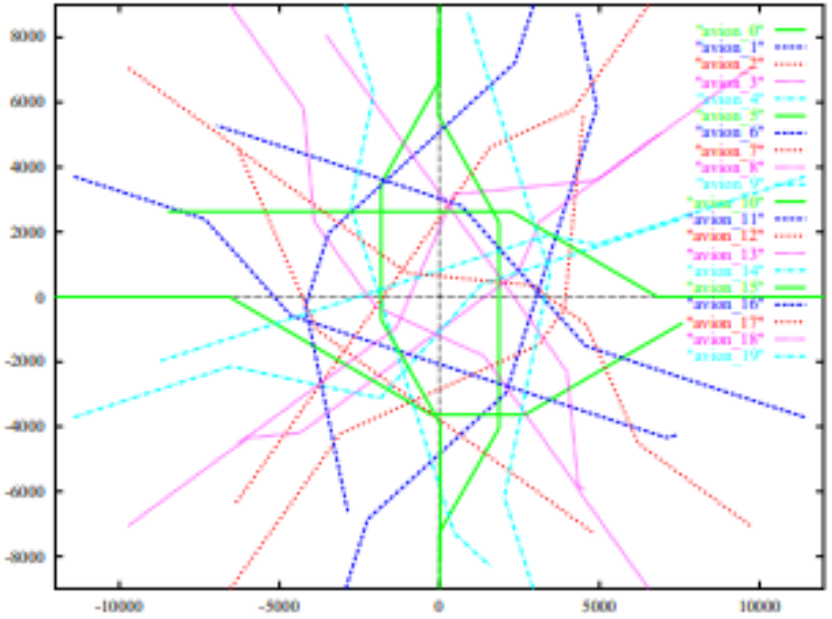
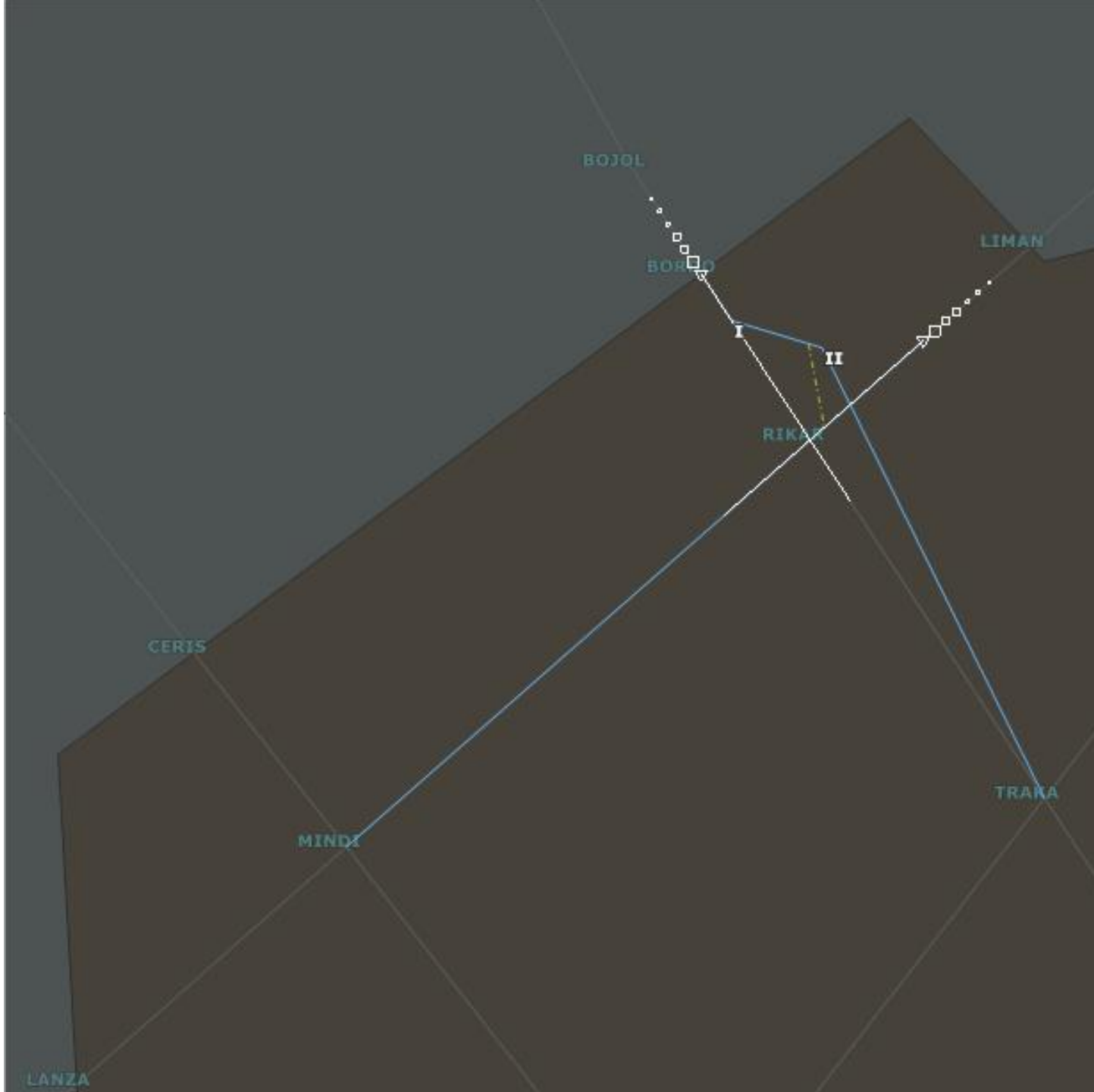




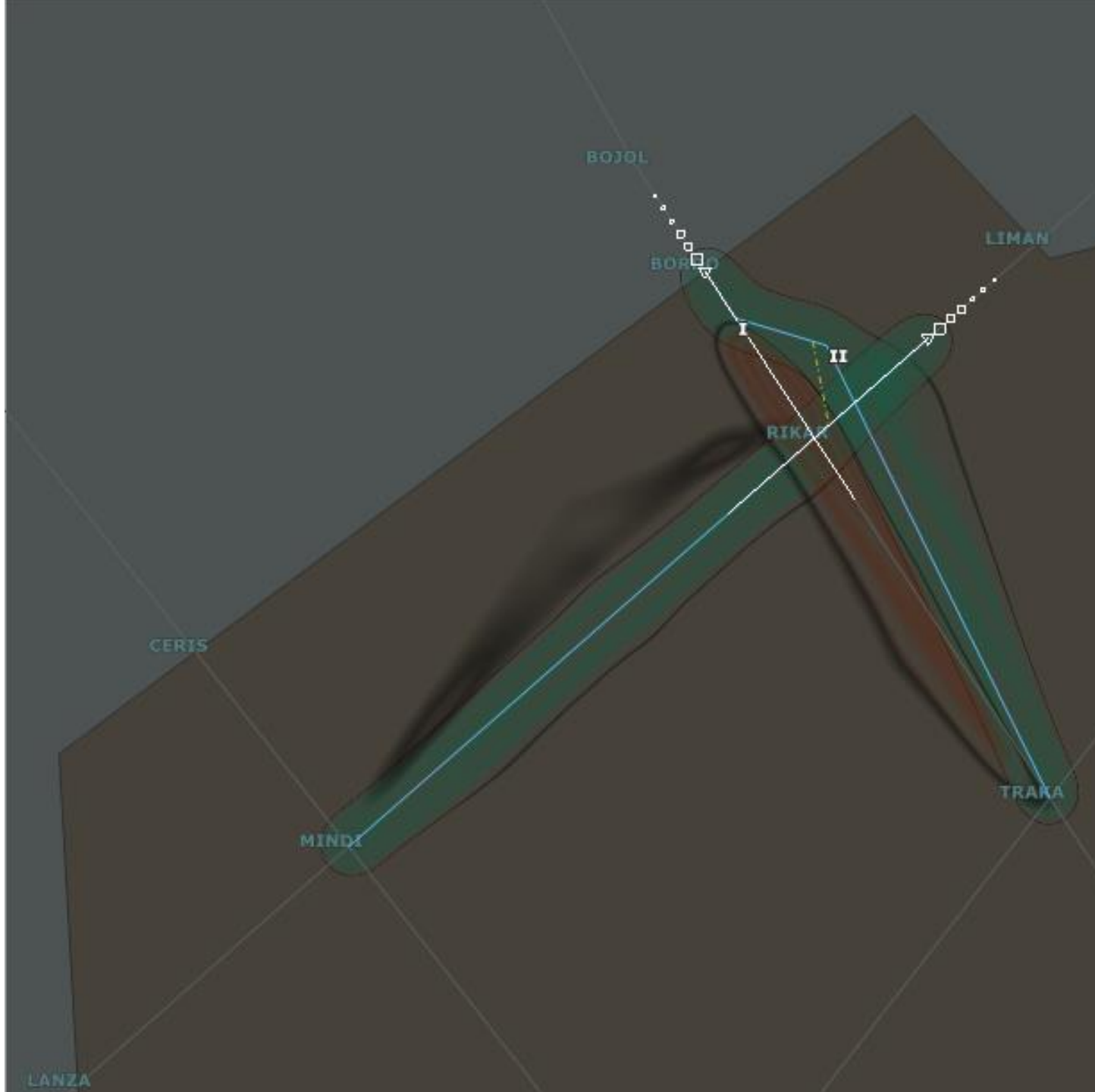


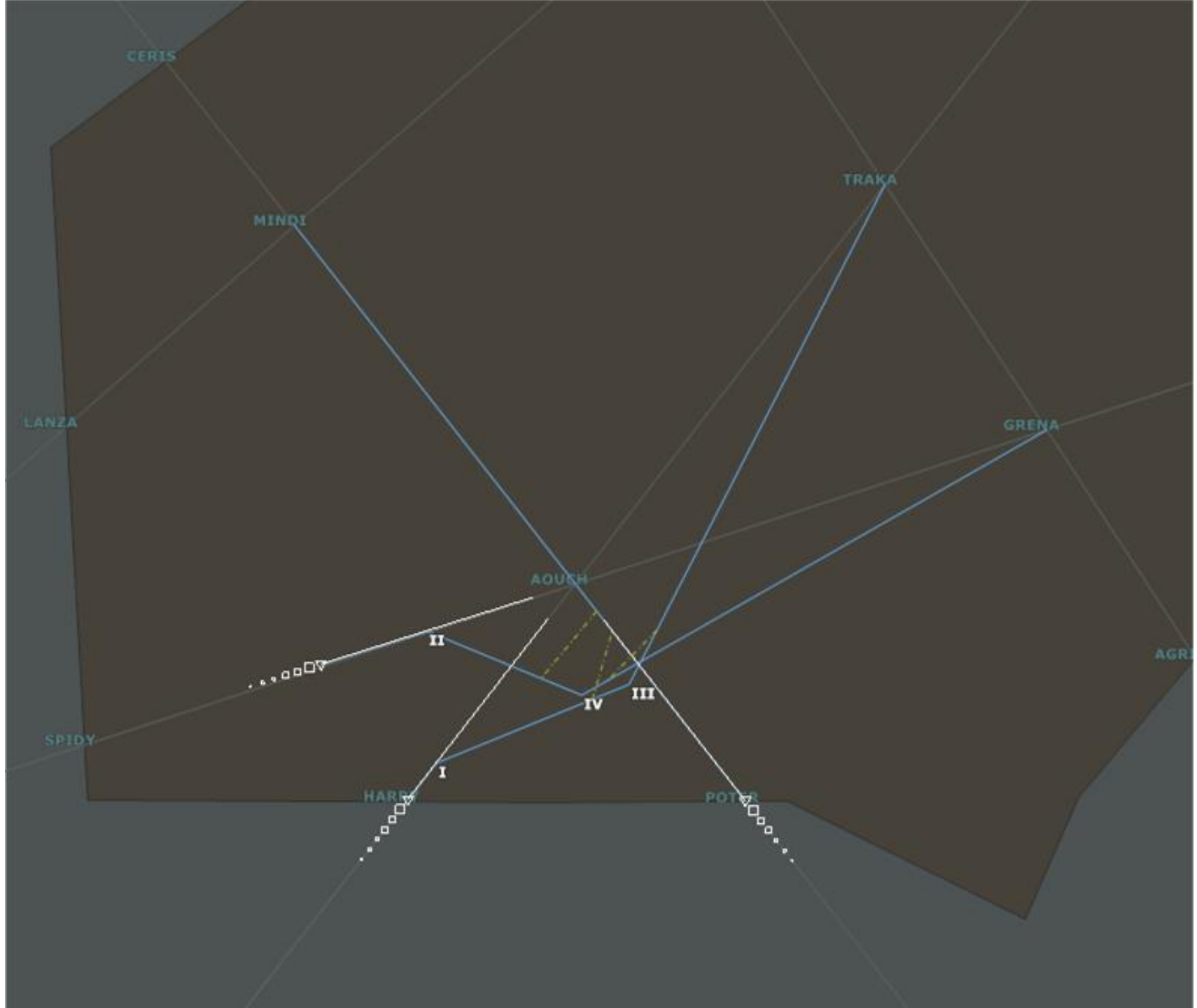
Durand, N., Alliot, J. M., & Noailles, J. (1996, February). Automatic aircraft conflict resolution using genetic algorithms. In *Proceedings of the 1996 ACM symposium on Applied Computing* (pp. 289-298).

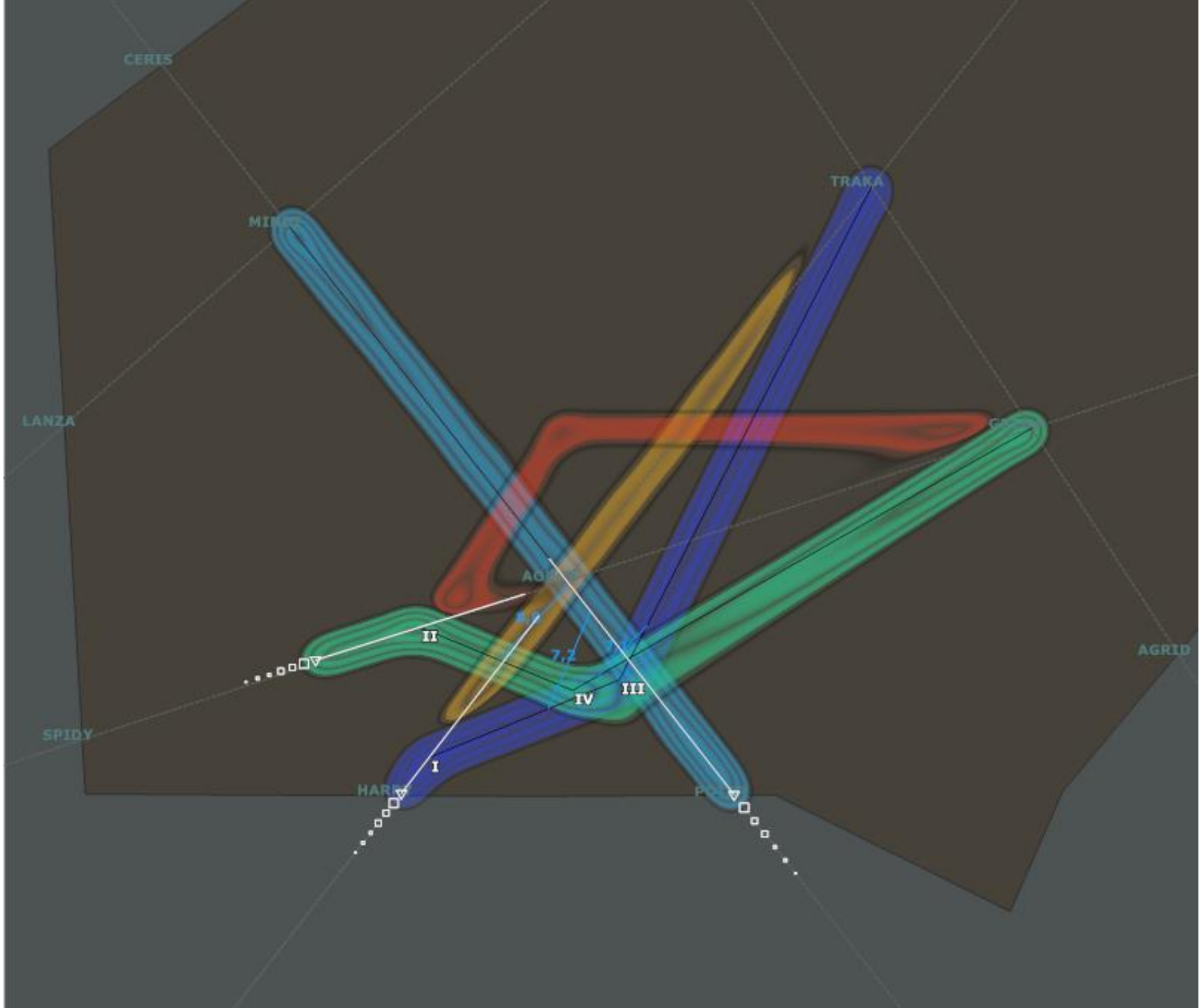
Two aircraft crossing

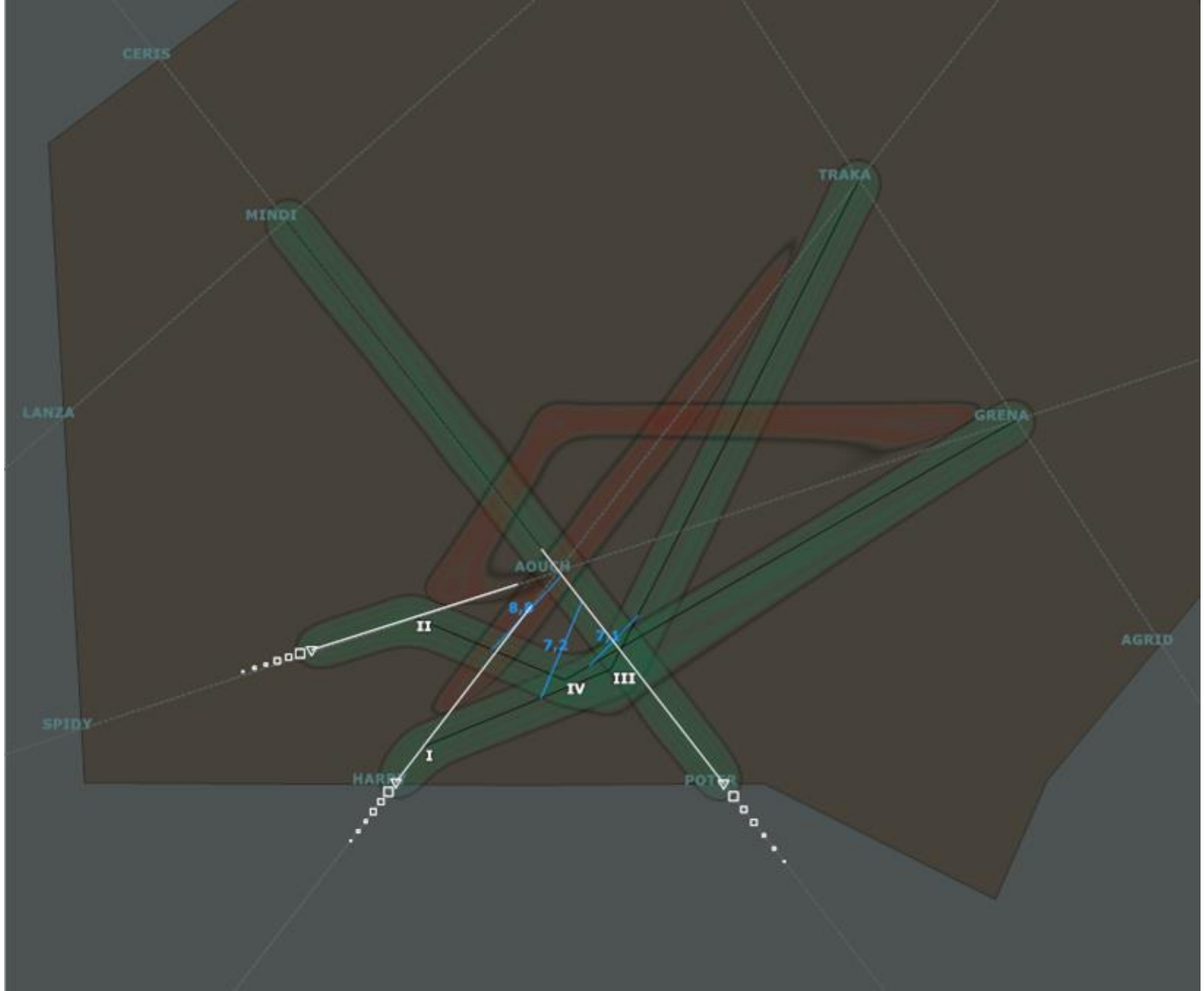


Two aircraft crossing



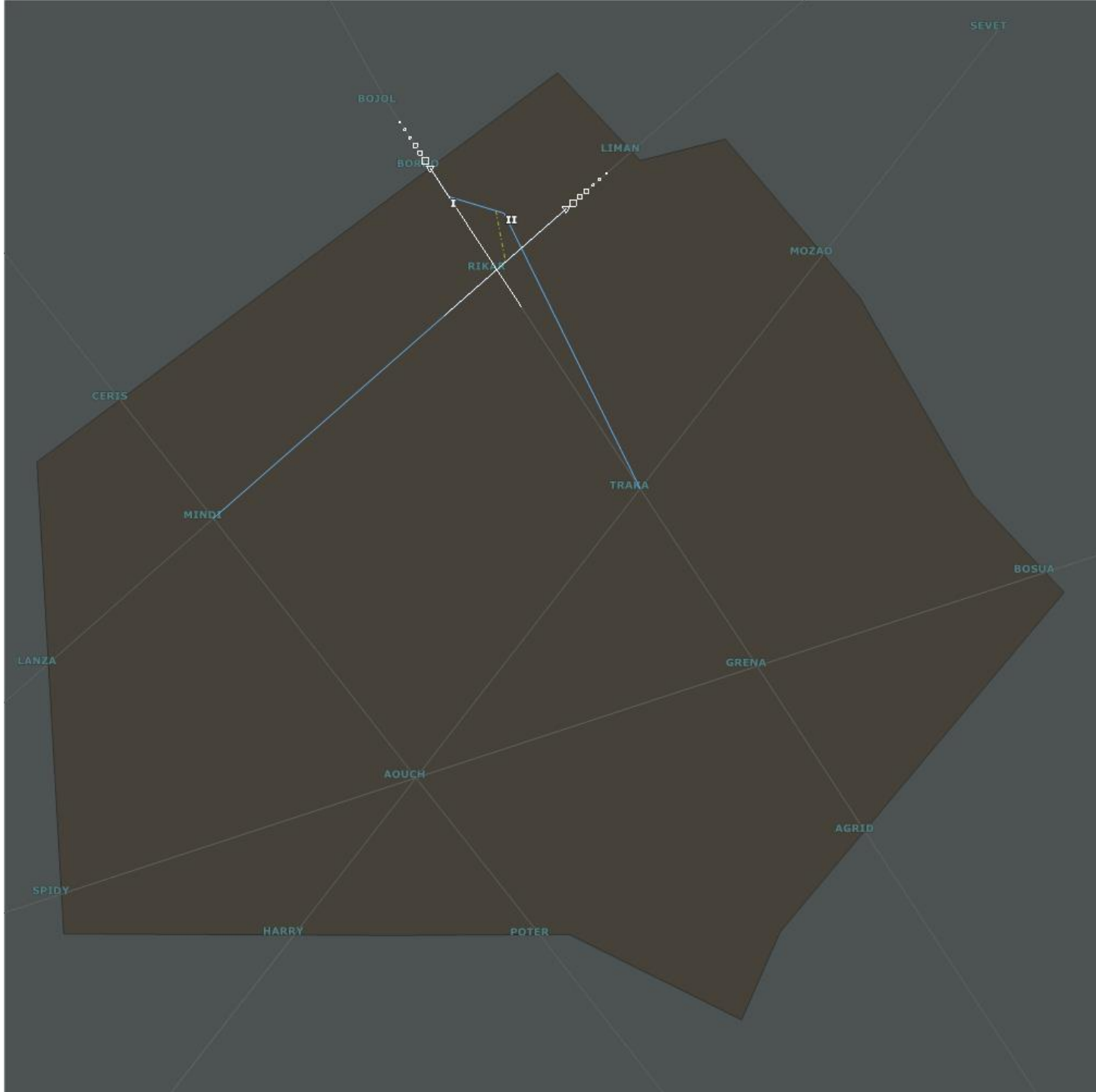

CERIS
TRAKA
MINDI
LANZA
GRENA
AOUSH
II
III
IV
I
SPIDY
HARPY
POTTER


CERES
TRAKA
LANZA
AGRID
SPIDY
II
III
IV
I

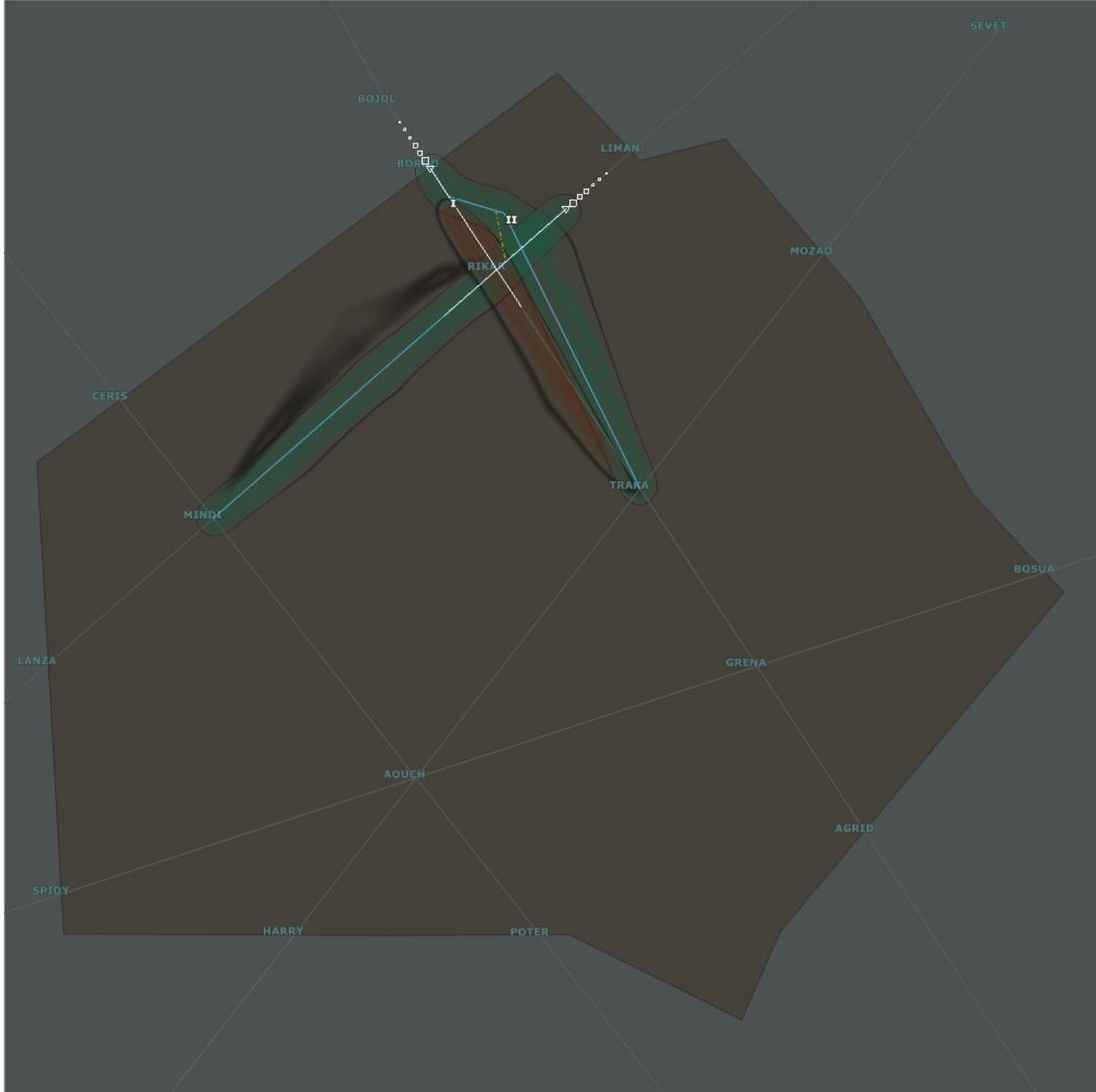

CERIS
TRAKA
MINDI
LANZA
GRENA
AGRID
SPIDY
II
III
IV
I
7,2

Three levels of algorithm transparency

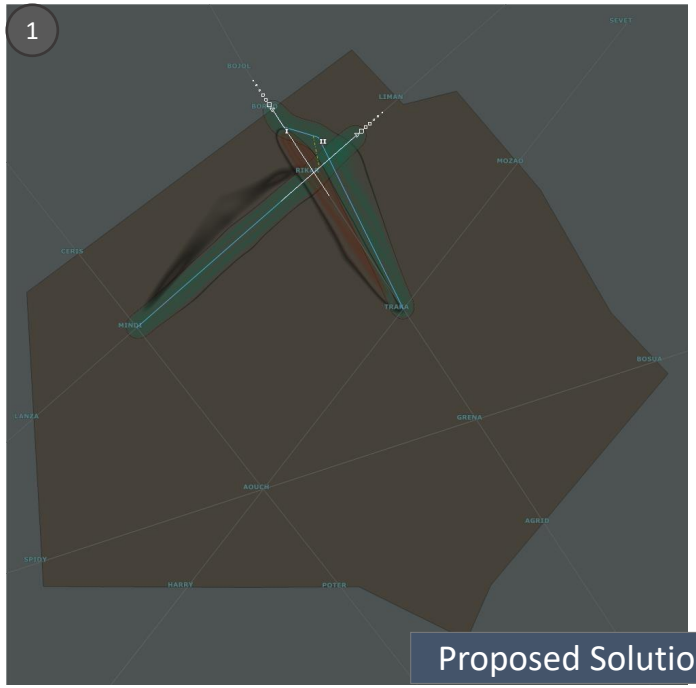
BB: Black Box

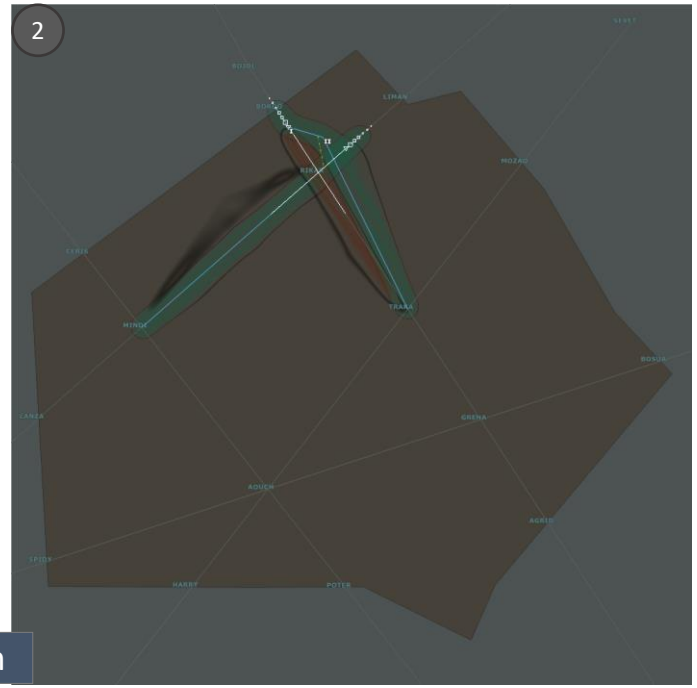

SEVET
BOJOL
LIMAN
I
II
MOZAO
CERIS
TRAKA
MINDI
BOSUA
LANZA
GRENA
AOUCH
AGRID
SPIDY
HARRY
POTER

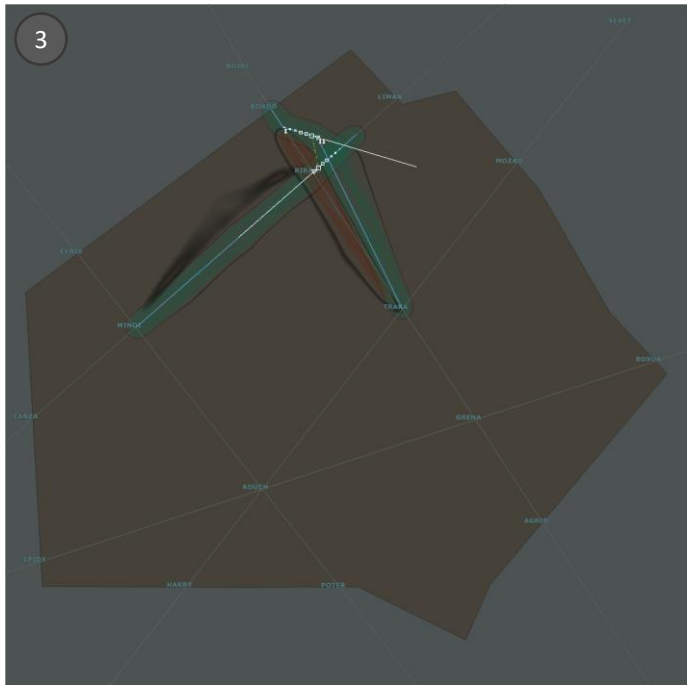
HM: Heatmap


SEVET
BOJOL
LIMAN
I
II
MOZAO
RIKAM
CERIS
TRAKA
MINDI
BOSUA
LANZA
GRENA
AOUCH
AGRID
SPIDY
HARRY
POTER

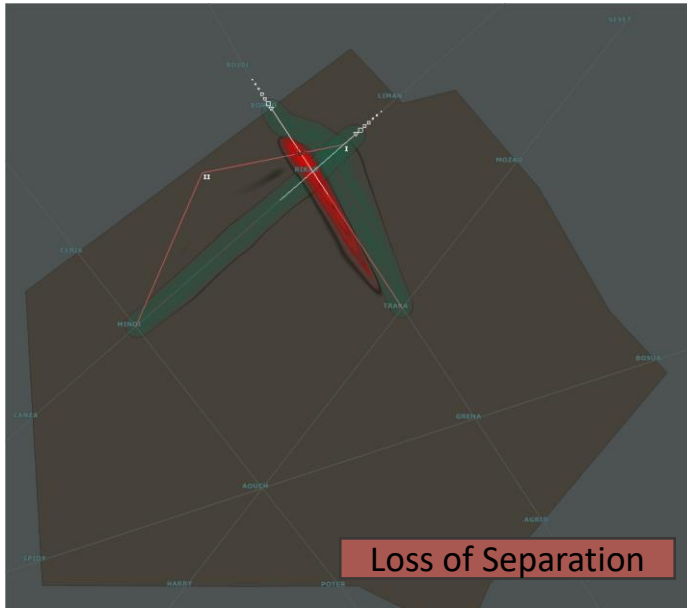
SB : Storyboard



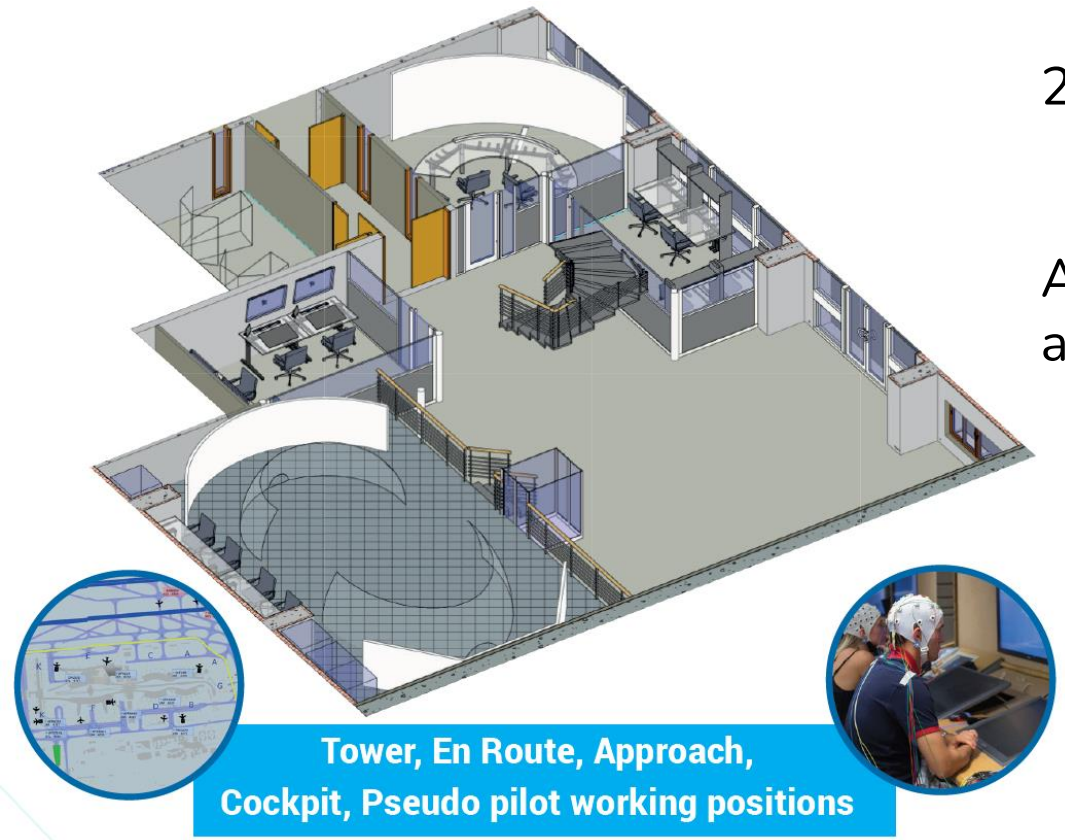




Proposed Solution



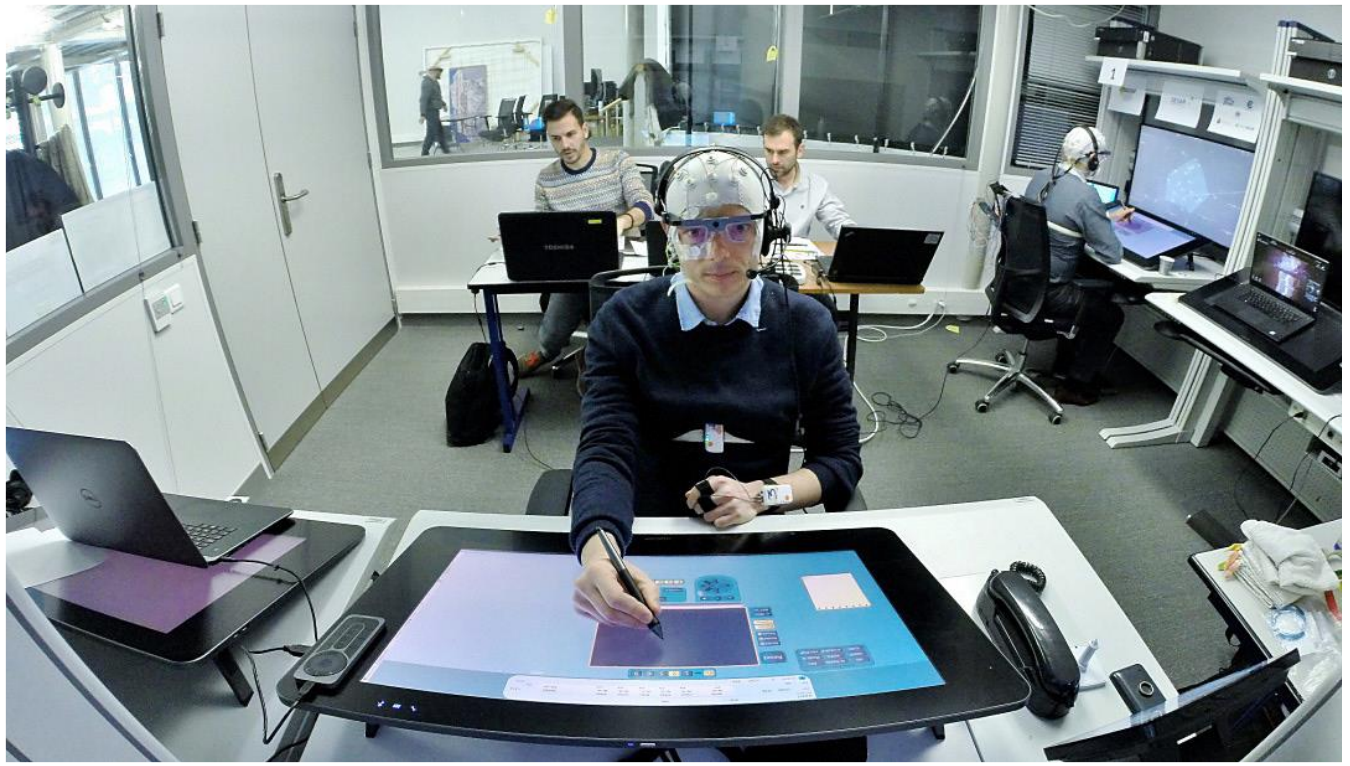
Experimentation Setting



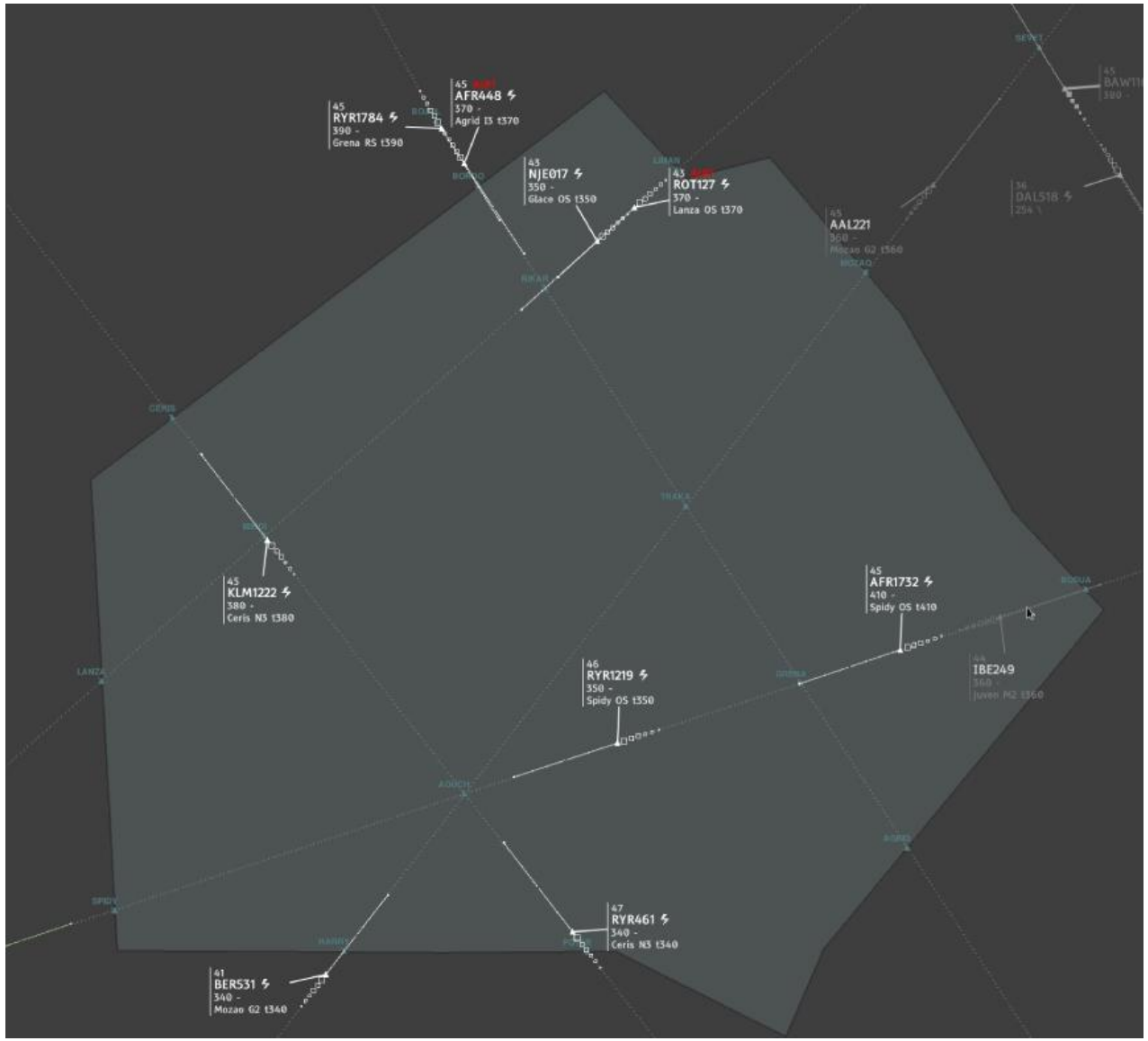
21 Air Traffic Controllers (11 students, 10 experts)

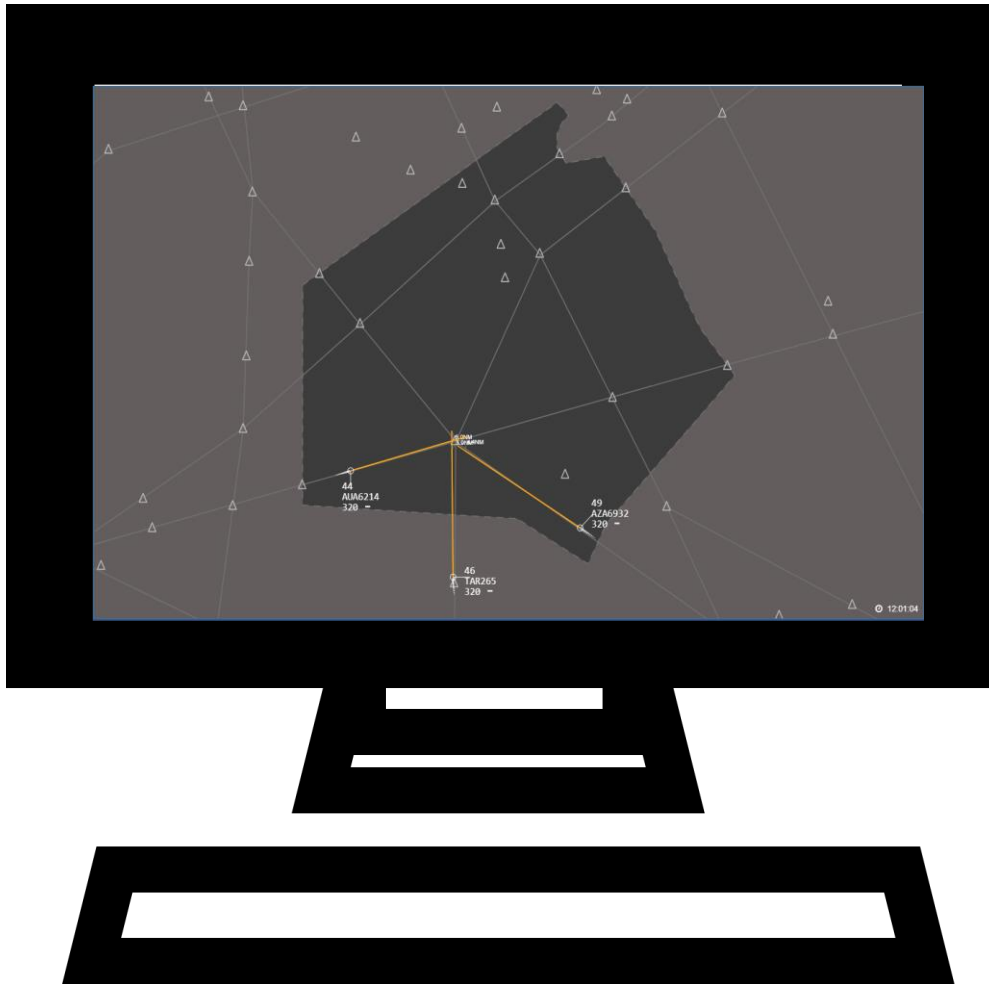
2 scenarios for each *condition* (Easy Hard)
Black Box, *Heat Map*, *StoryBoard*

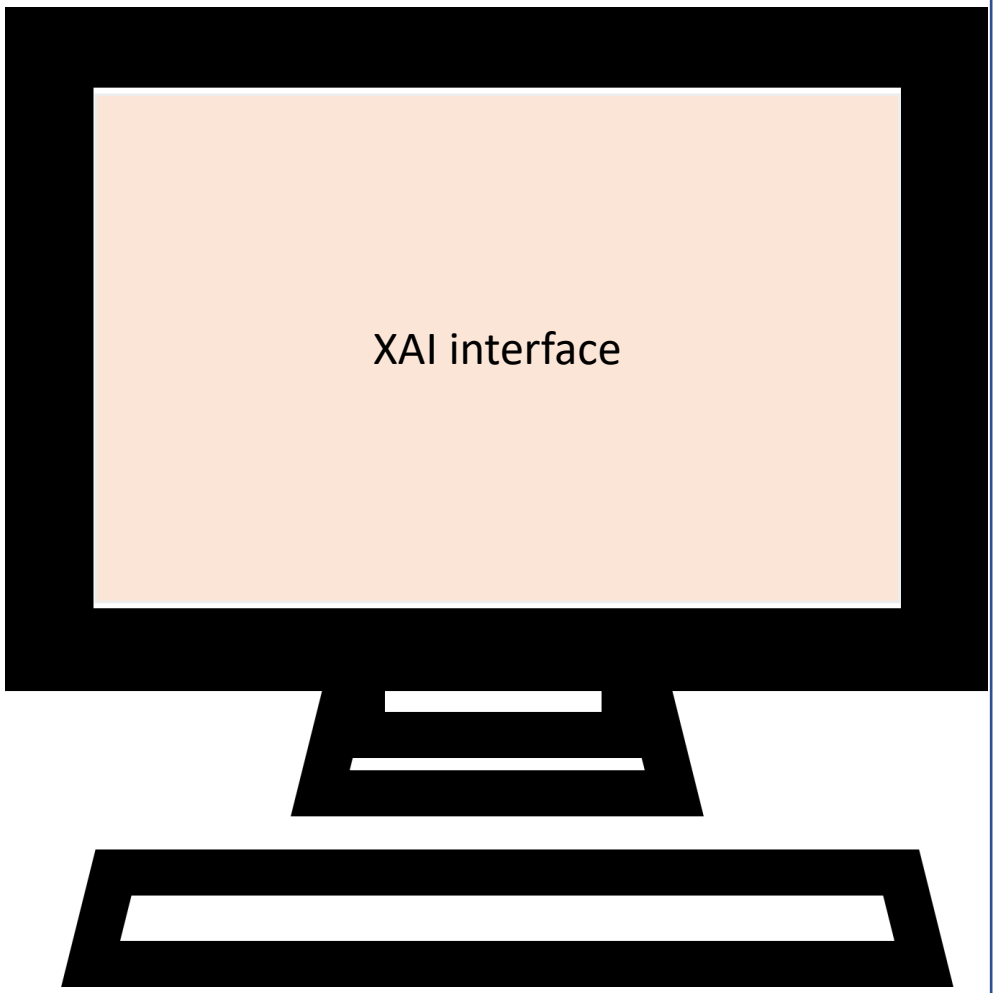
Assess the impact of each visualisation on the dimensions of acceptance, usability, human performance, work performance



Simulation Running 2 minutes







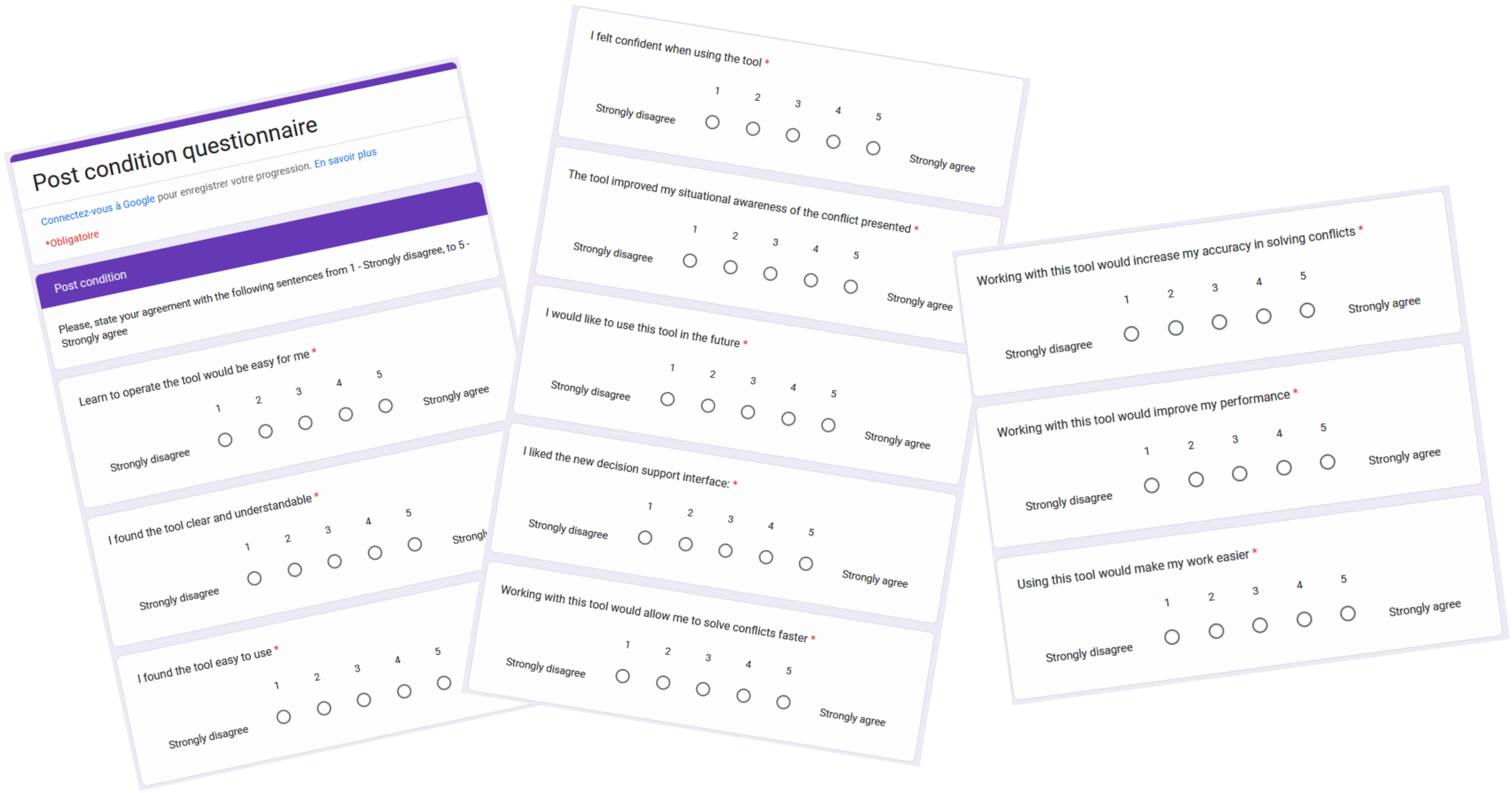
Conflict Avoidance Scenario → AI algorithm → XAI Condition → Conflict Avoidance Resolution

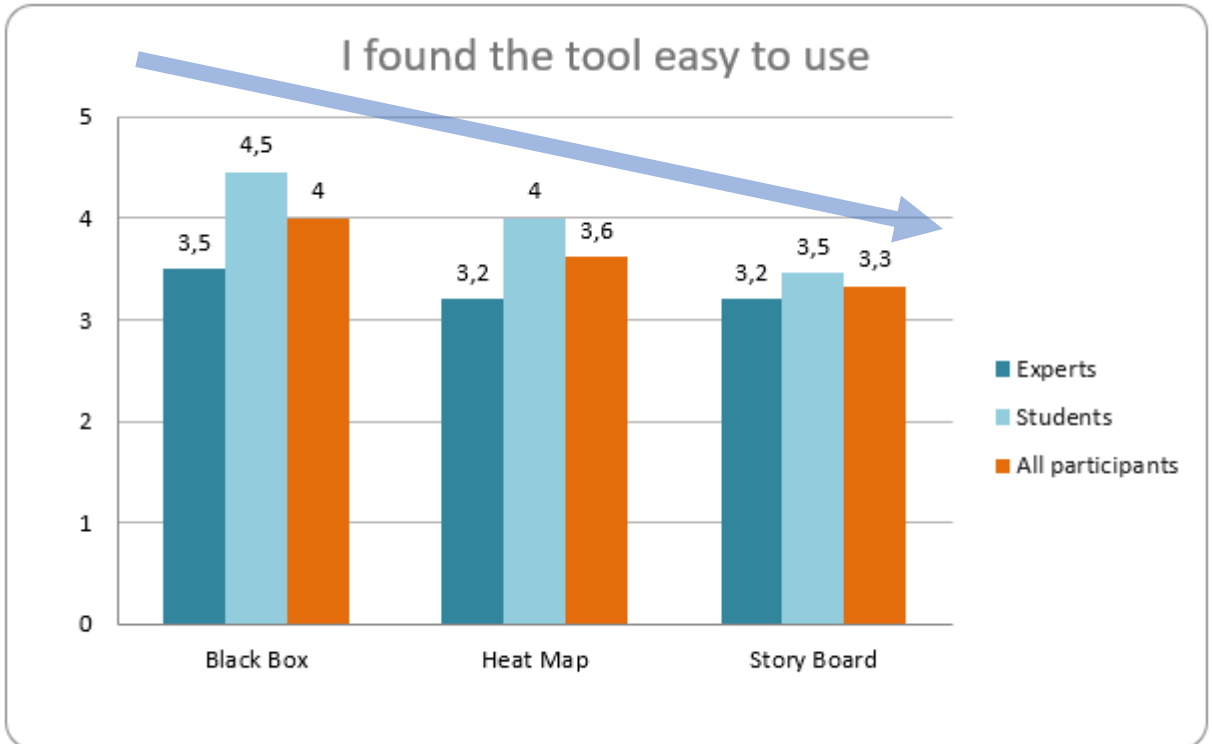
Condition 0: **BB** - Black Box

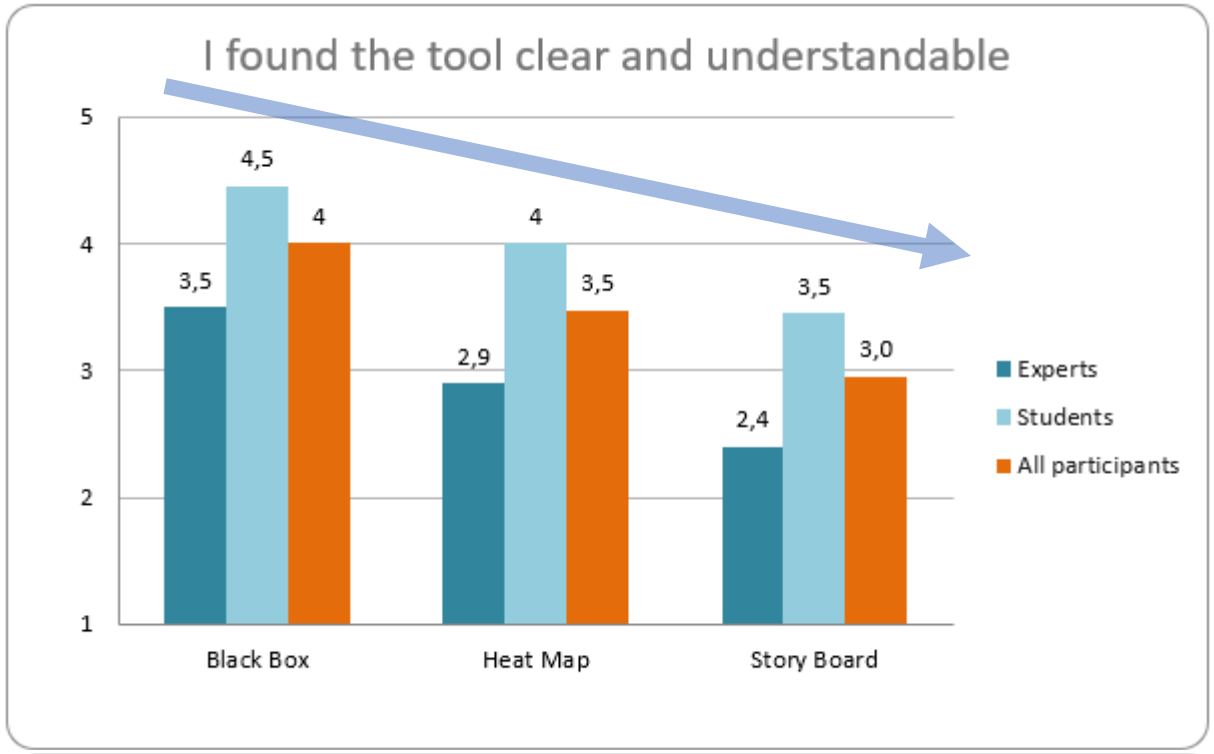
Condition 1: **HM** - Heatmap

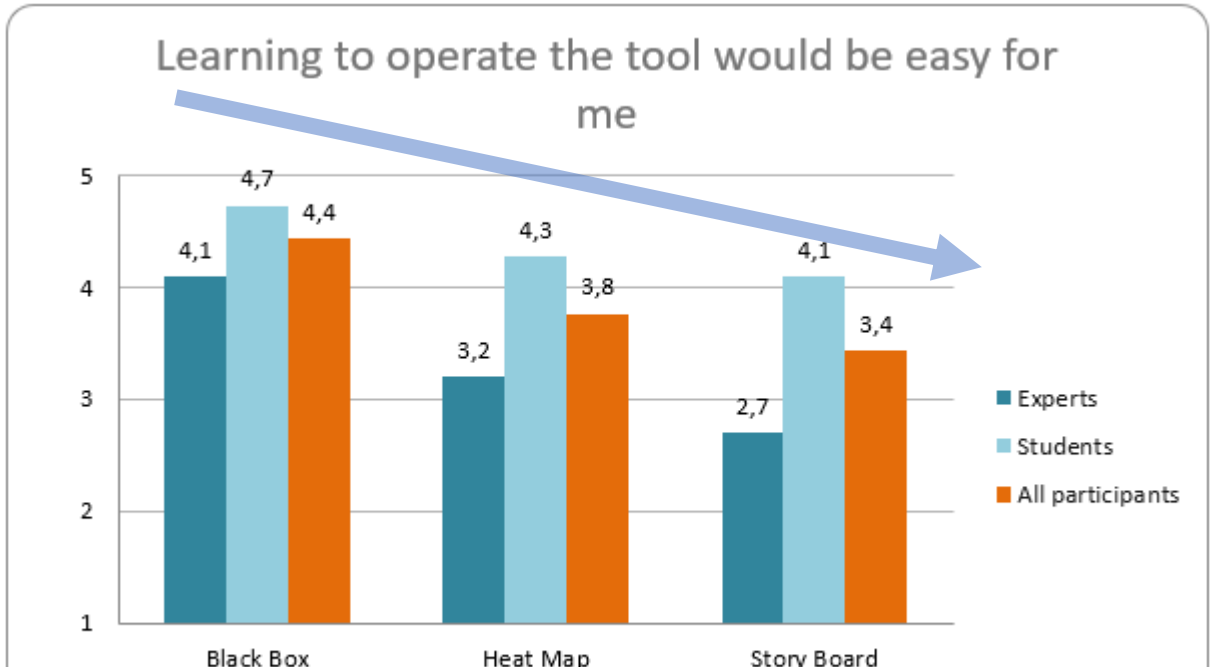
Condition 3: **SB** - Storyboard

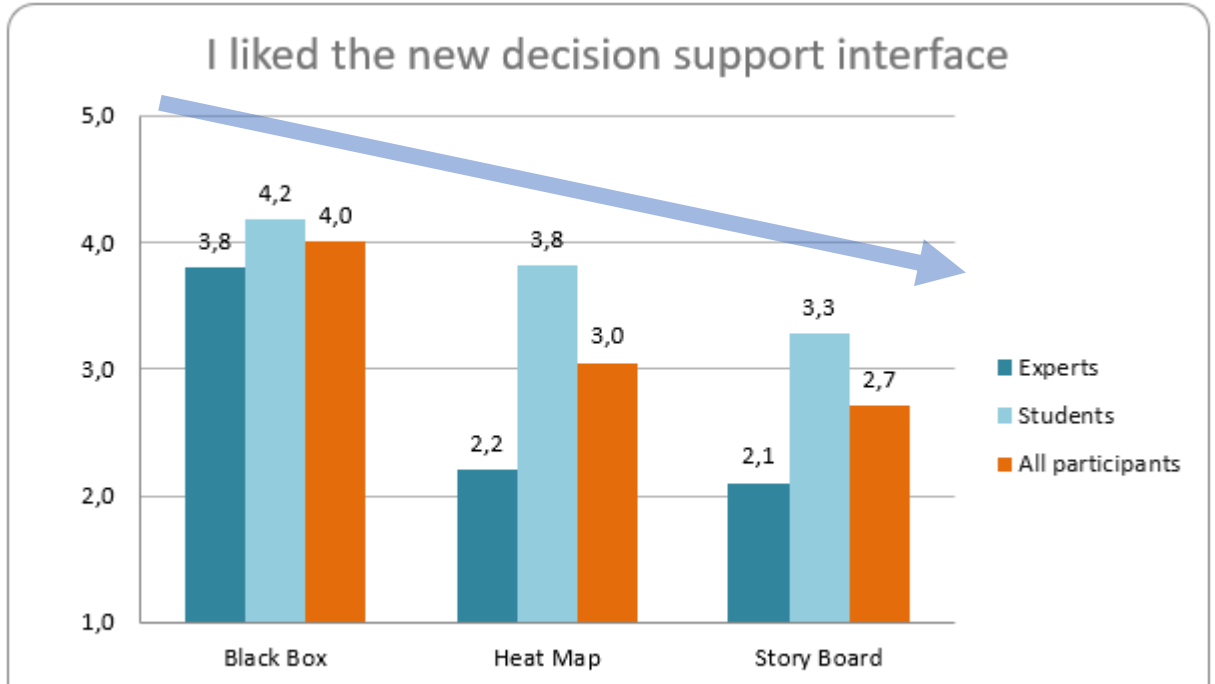
Preliminary Results



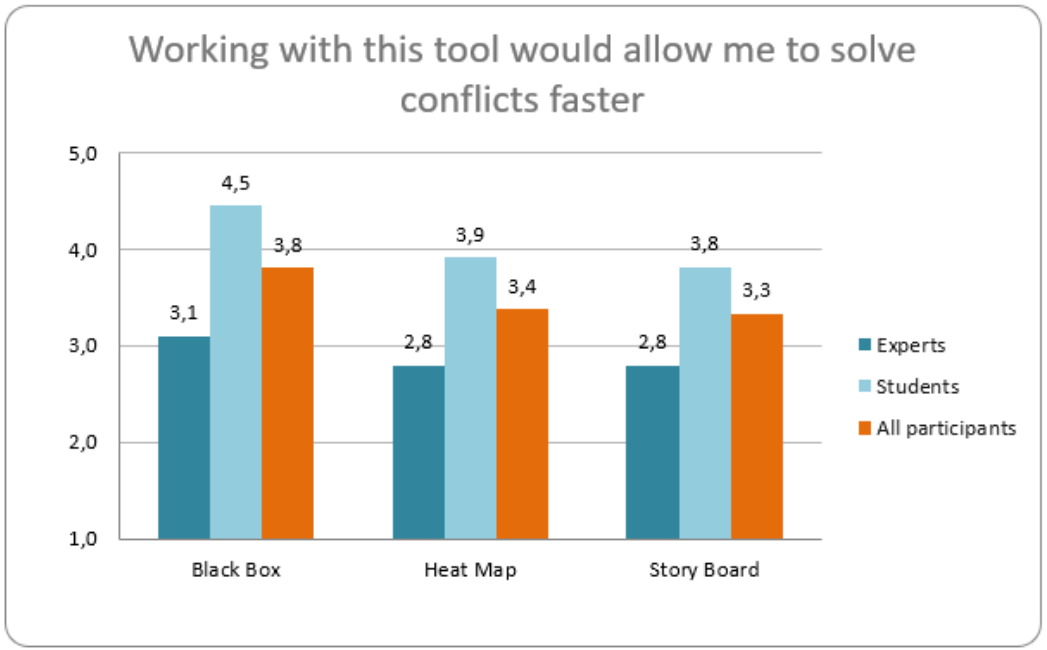

I found the tool easy to use
5
4
3
2
1
0
3,5
4,5
4
3,2
4
3,6
3,2
3,5
3,3
Black Box
Heat Map
Story Board
Experts
Students
All participants

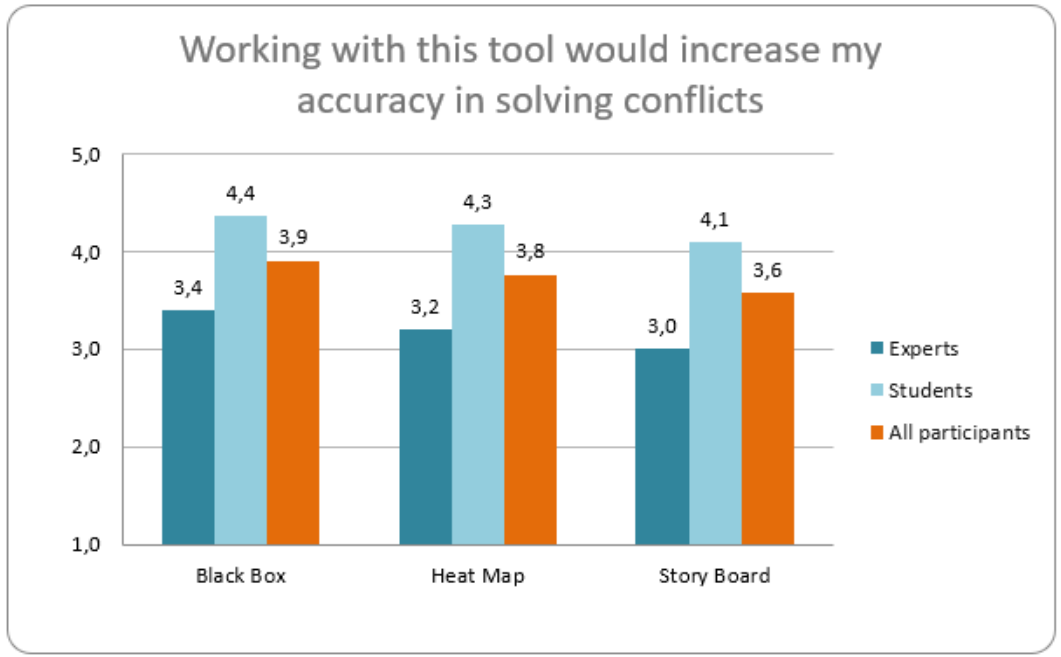

I found the tool clear and understandable
5
4
3
2
1
3,5
4,5
4
2,9
4
3,5
2,4
3,5
3,0
Black Box
Heat Map
Story Board
Experts
Students
All participants

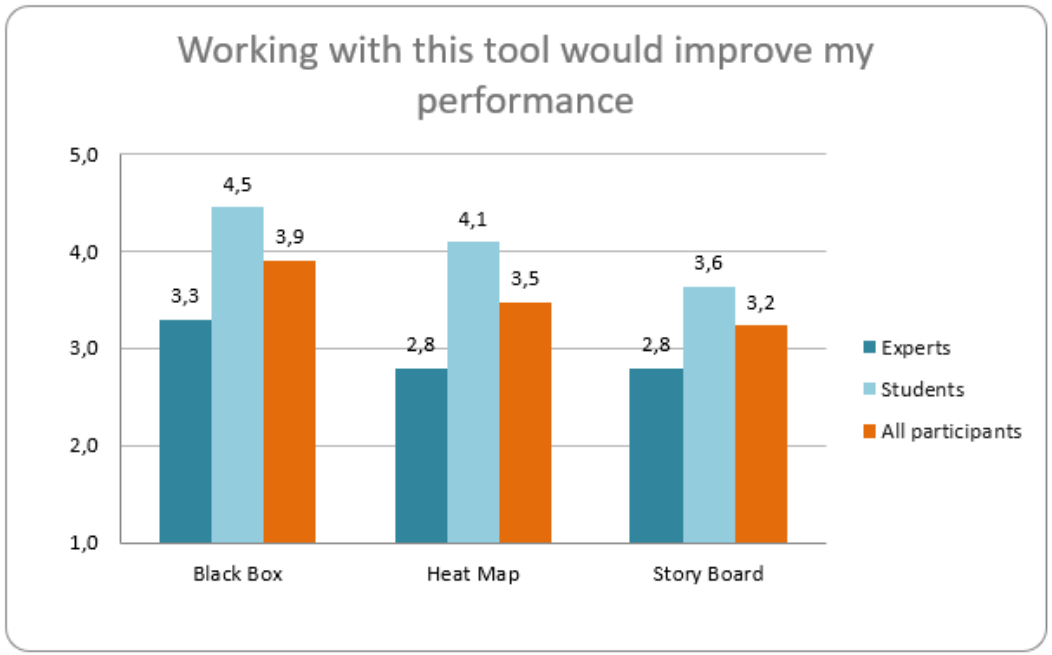

Learning to operate the tool would be easy for me
5
4
3
2
1
4,1
4,7
4,4
3,2
4,3
3,8
2,7
4,1
3,4
Black Box
Heat Map
Story Board
Experts
Students
All participants

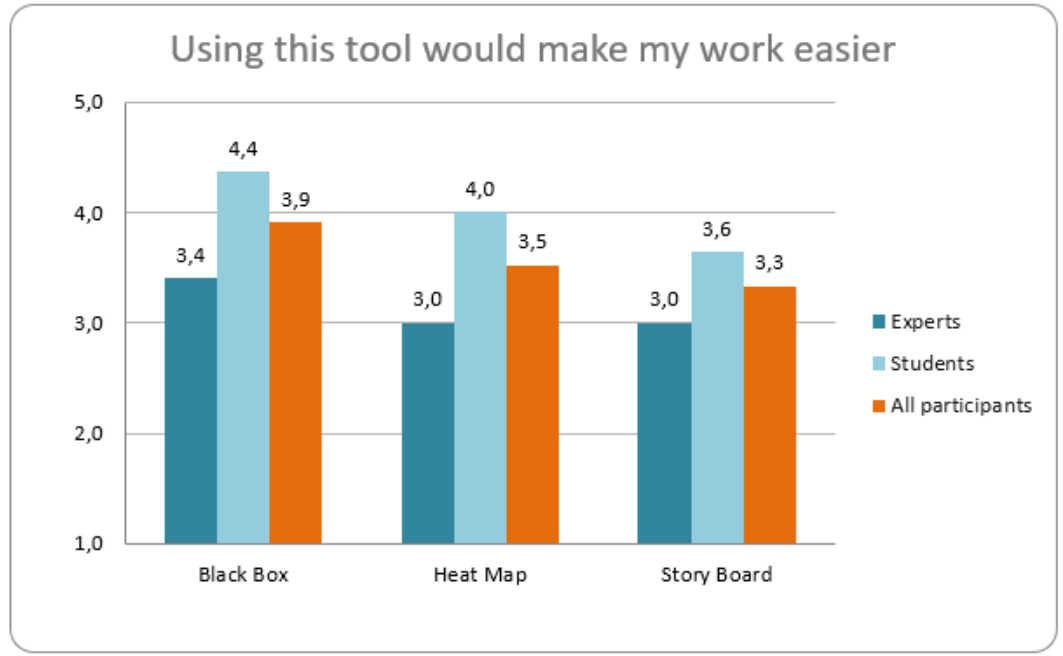

I liked the new decision support interface
5,0
4,0
3,0
2,0
1,0
3,8
4,2
4,0
2,2
3,8
3,0
2,1
3,3
2,7
Black Box
Heat Map
Story Board
Experts
Students
All participants

Impact on performance and operational support

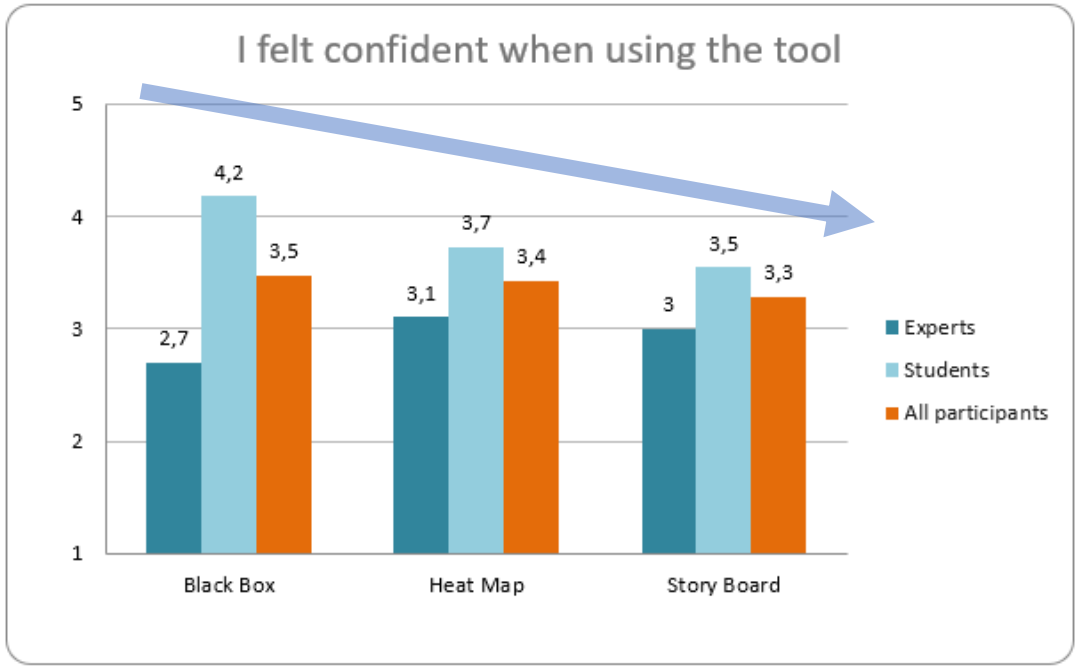




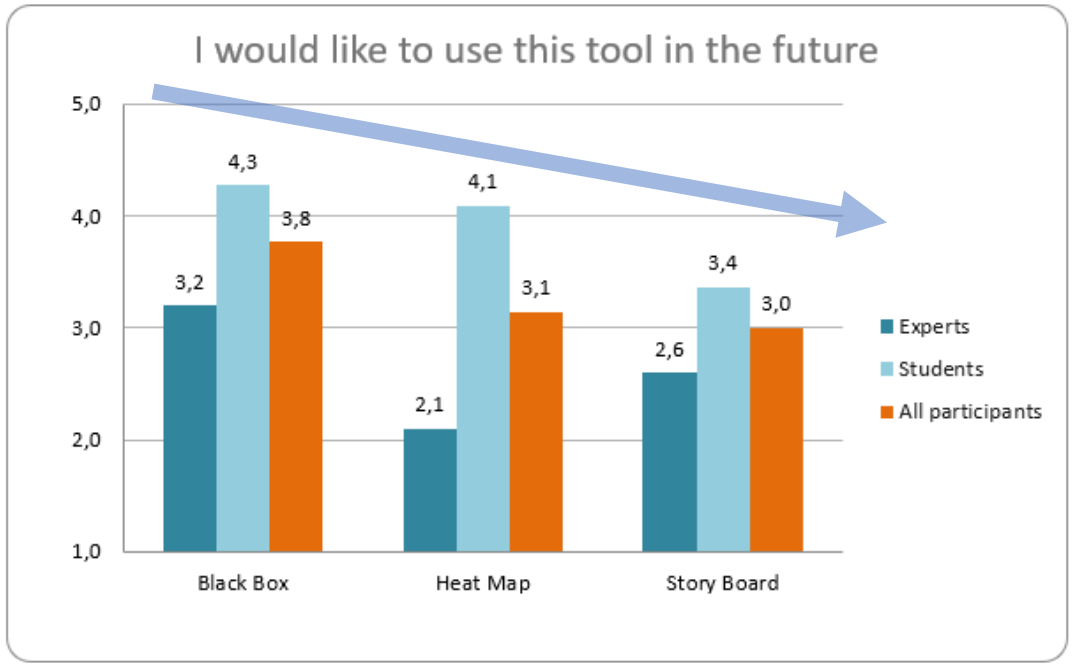




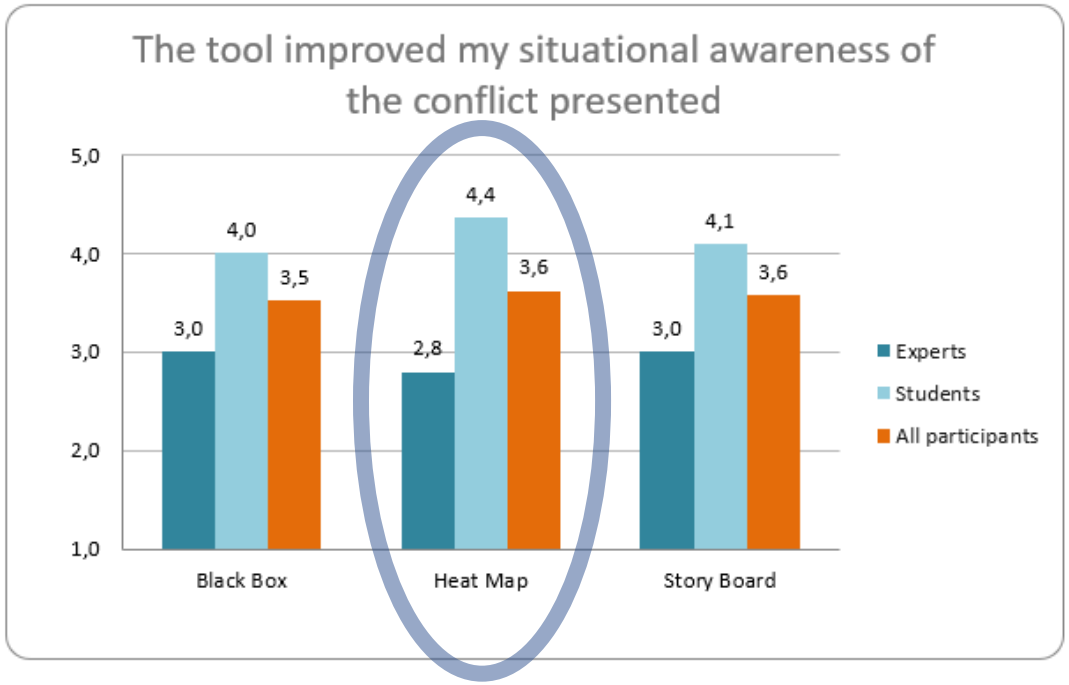
Trust

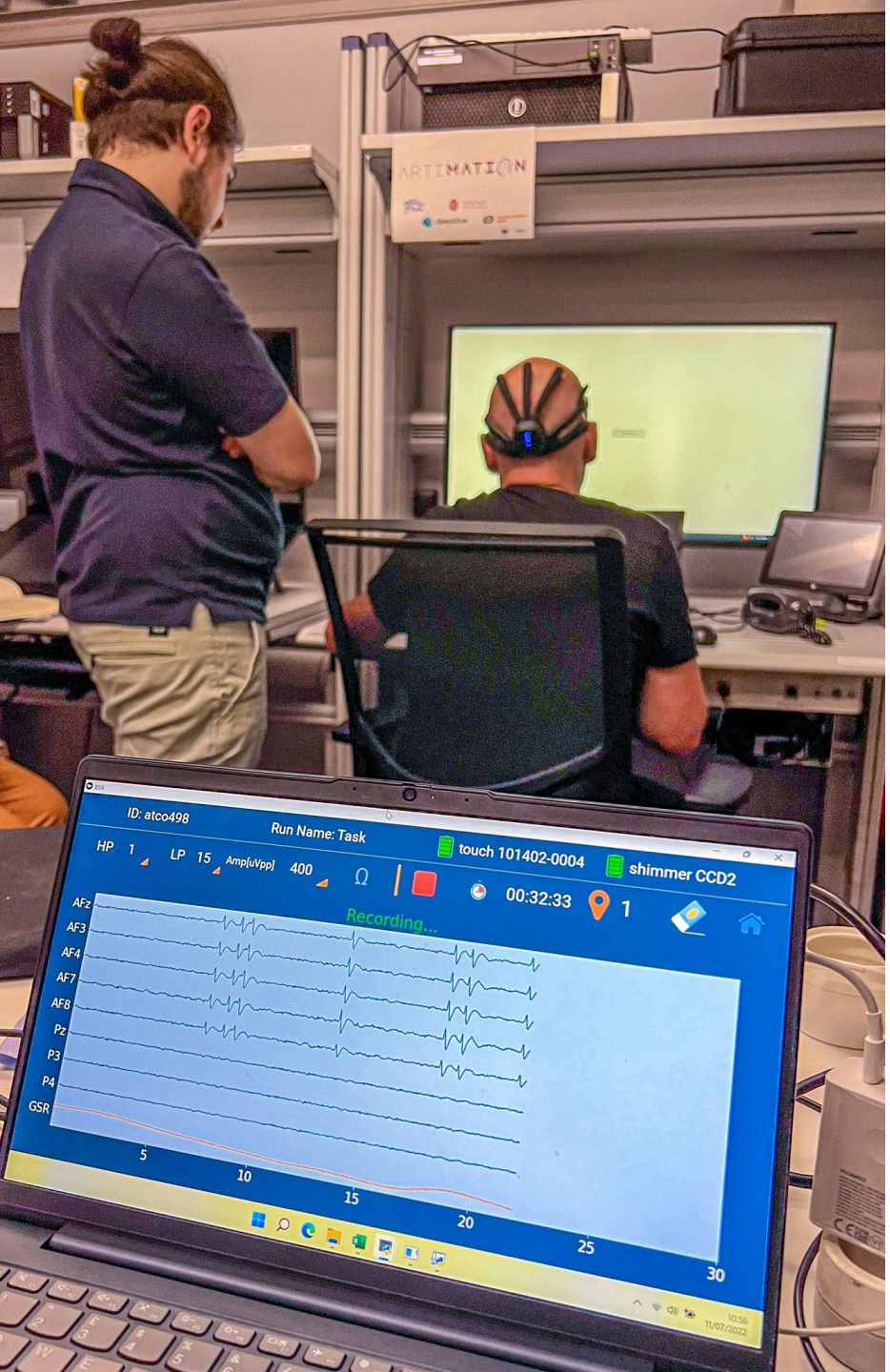


Acceptability



Situation Awareness

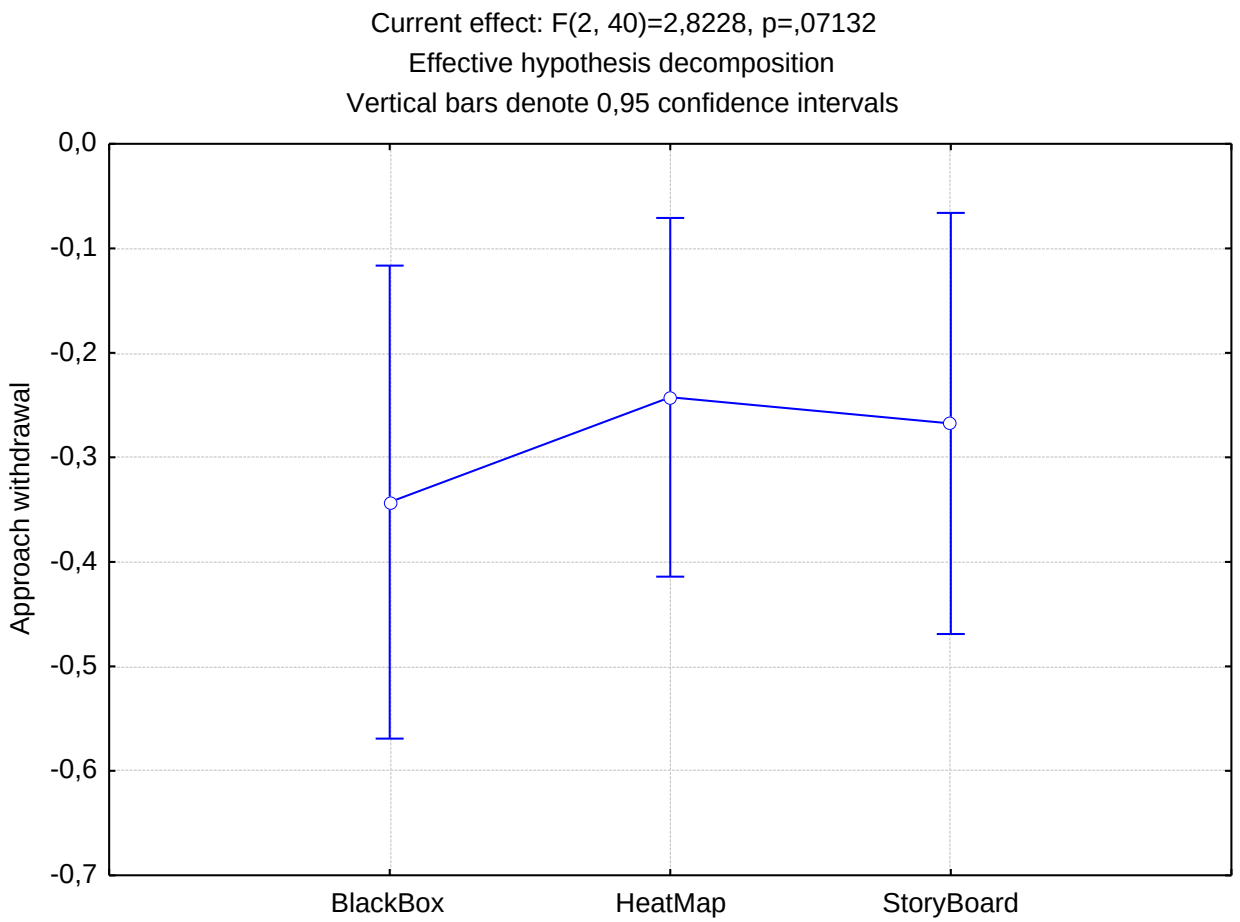




Preliminary Results

https://www.brainsigns.com

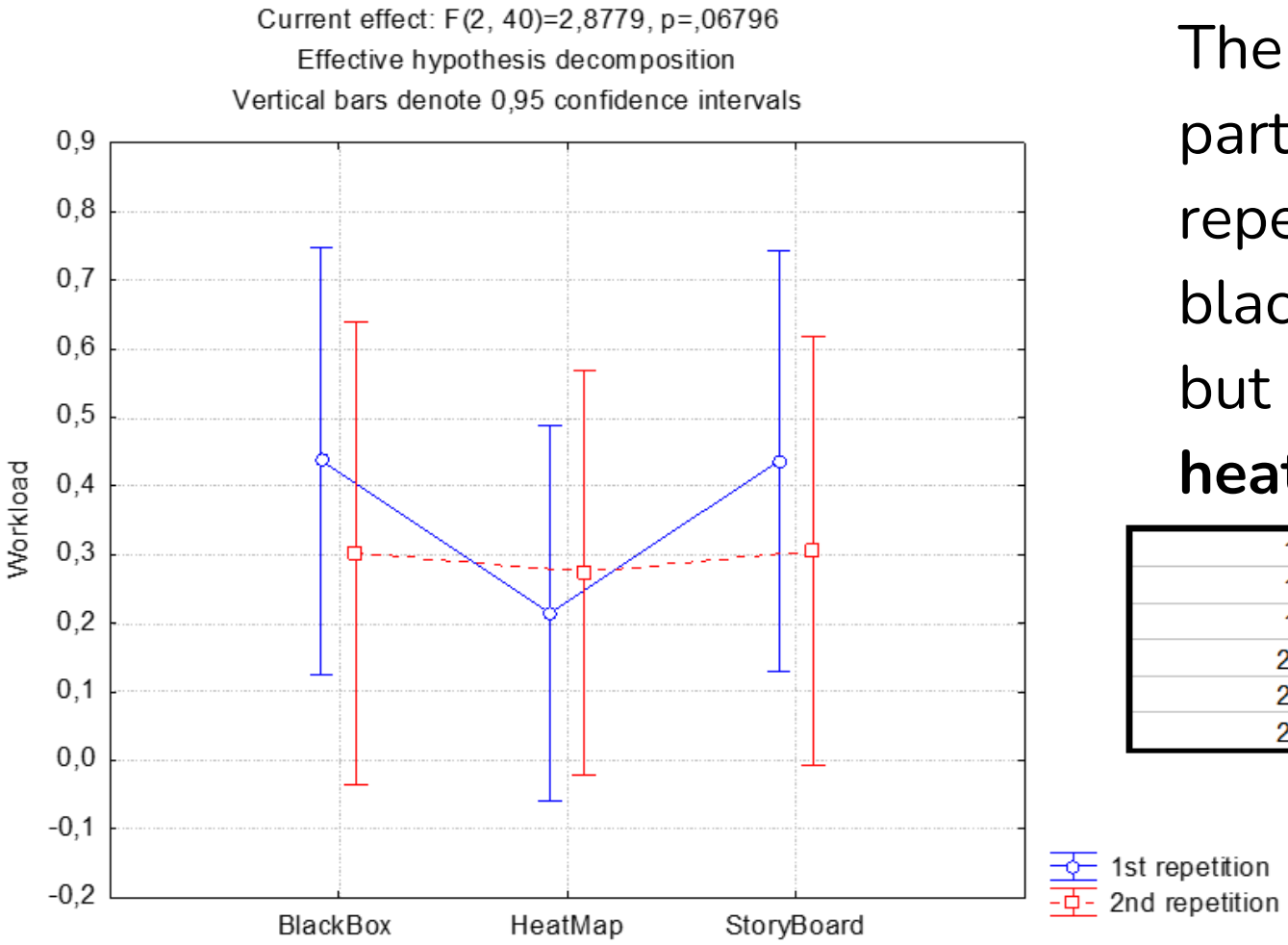
Some preliminary results: Approach-Withdrawal



The **acceptability** of the two solutions with XAI was significantly higher with respect to the black box condition

BlackBox		0,035657	0,094591
HeatMap	0,035657		0,572333
StoryBoard	0,094591	0,572333	

Some preliminary results: Workload



The **Workload** experienced by the participants among the two repetitions, decreased during the blackbox and storyboard conditions, but was **already lower during the heatmap condition**.

1st	BlackBox		0,003739	0,998869	0,065581	0,030196	0,064383
1st	HeatMap	0,003739		0,003313	0,217483	0,369798	0,214711
1st	StoryBoard	0,998869	0,003313		0,057580	0,026965	0,052227
2nd	BlackBox	0,065581	0,217483	0,057580		0,675436	0,955646
2nd	HeatMap	0,030196	0,369798	0,026965	0,675436		0,656614
2nd	StoryBoard	0,064383	0,214711	0,052227	0,955646	0,656614	

Results

AI support and types of conflicts: the proposed AI solutions were not useful for conflicts with only two aircraft.

Human Machine Interface: Heat Maps were not straightforward to understand by ATCOs.

Trust and XAI: the main outcome from the collected feedback is that more trust is provided with transparent solution.

Safety: improved safety with user ‘in the decision loop’.

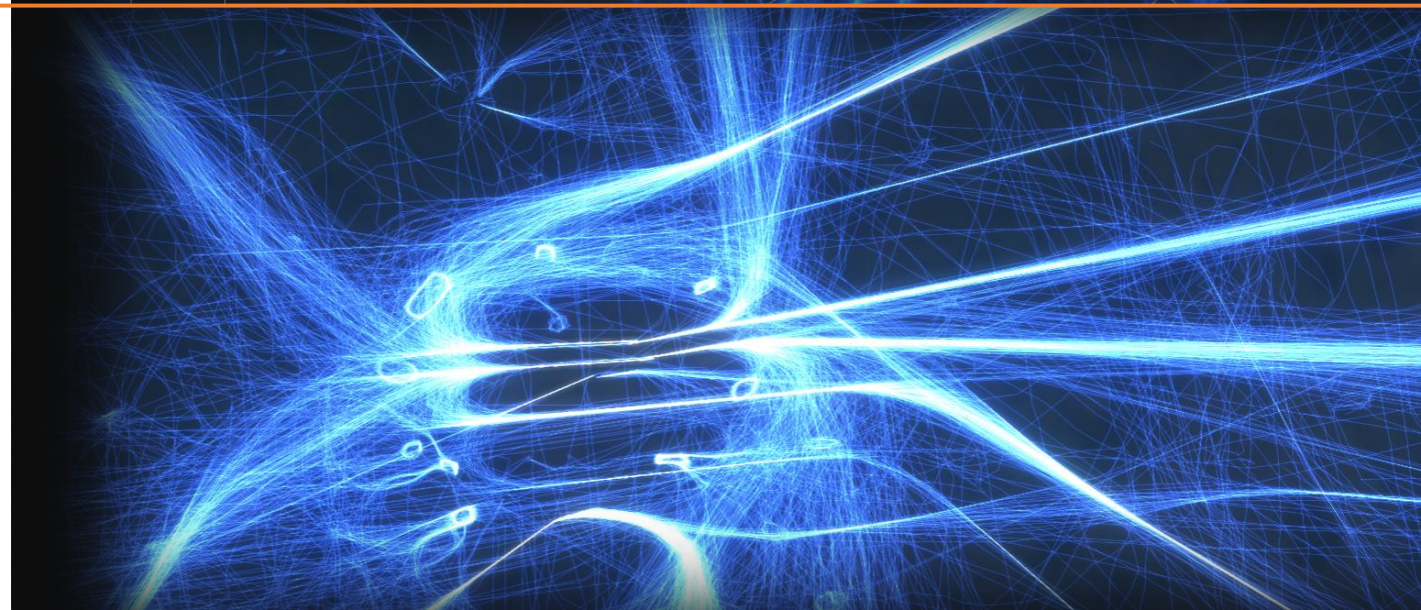
Training: five ATCOs mentioned that it would be interesting to explore and understand better the advantages of the XAI solutions for training.

Visual / Immersive Analytics

RenderLine
Next-generation of
Data Visualisation Tool

RenderLine

Next-Generation of Data Visualisation Tool



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Moteur de rendu de trajectoires en 3D

Un outil pour la communication et l'analyse

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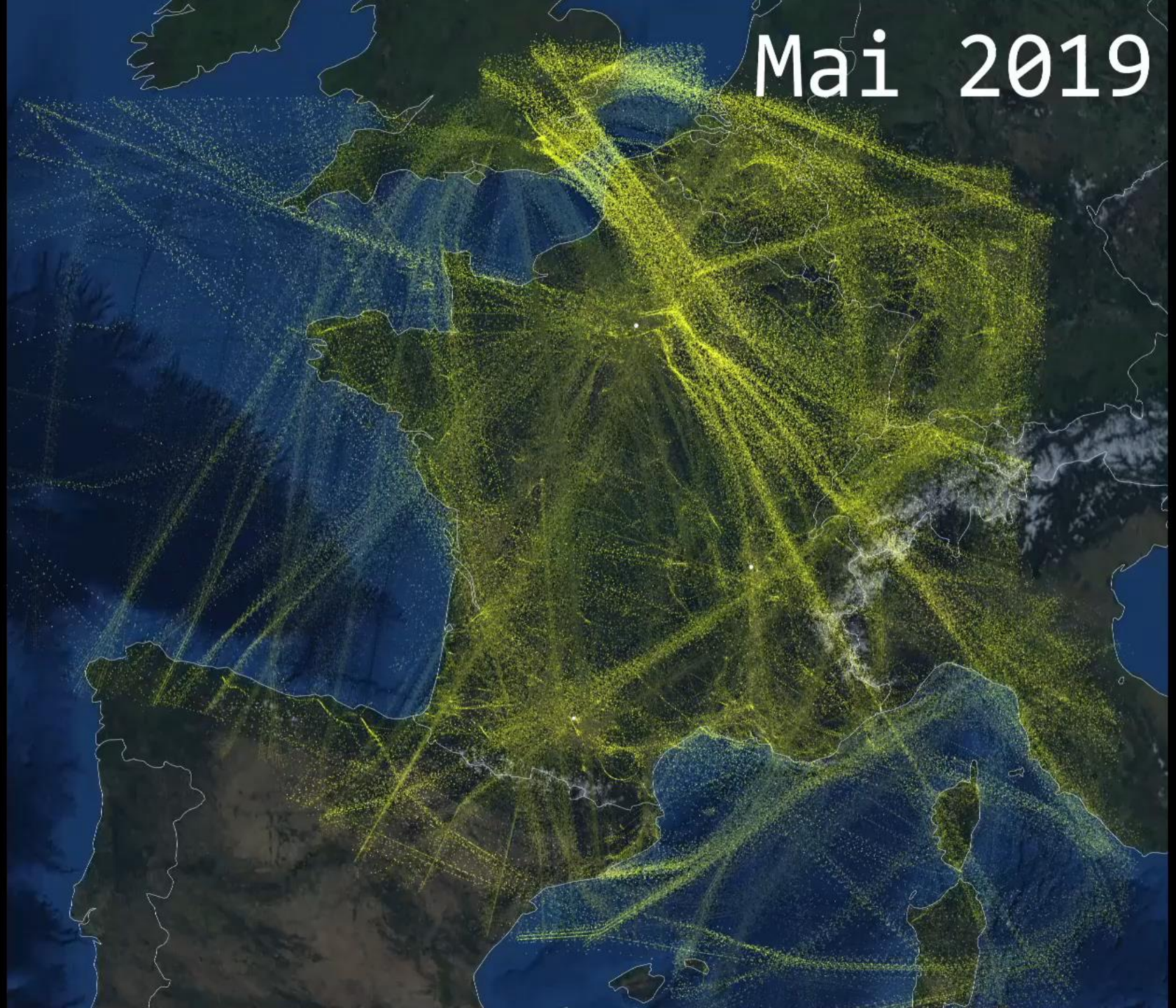
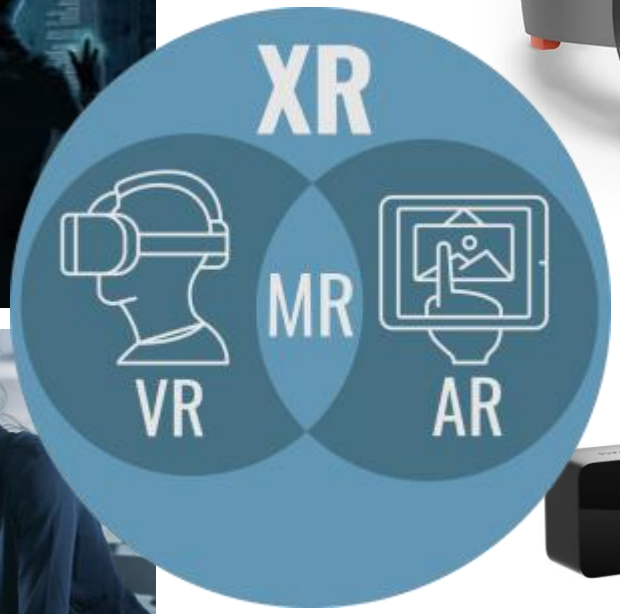

Mai 2019

Immersive Analytics



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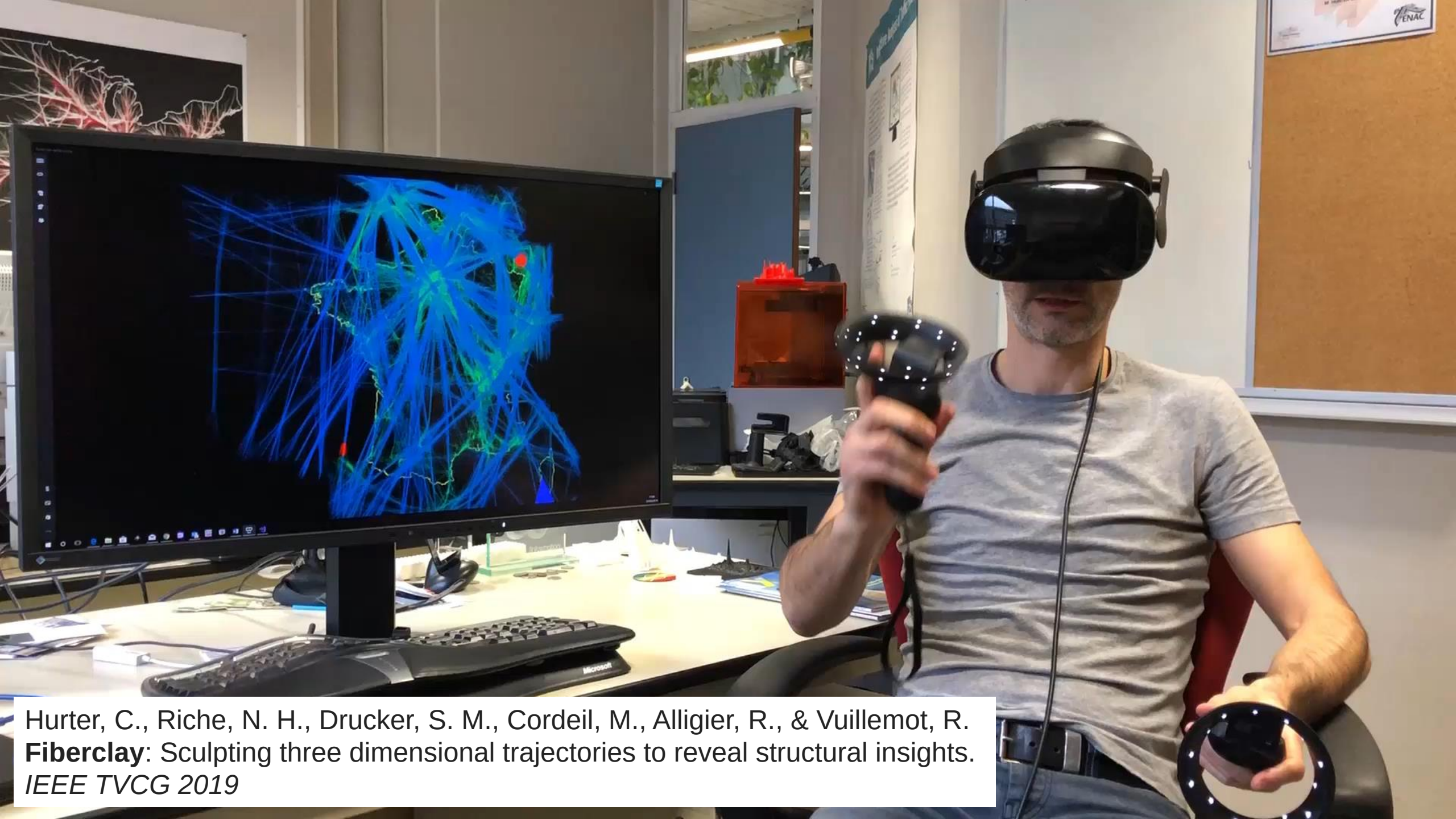
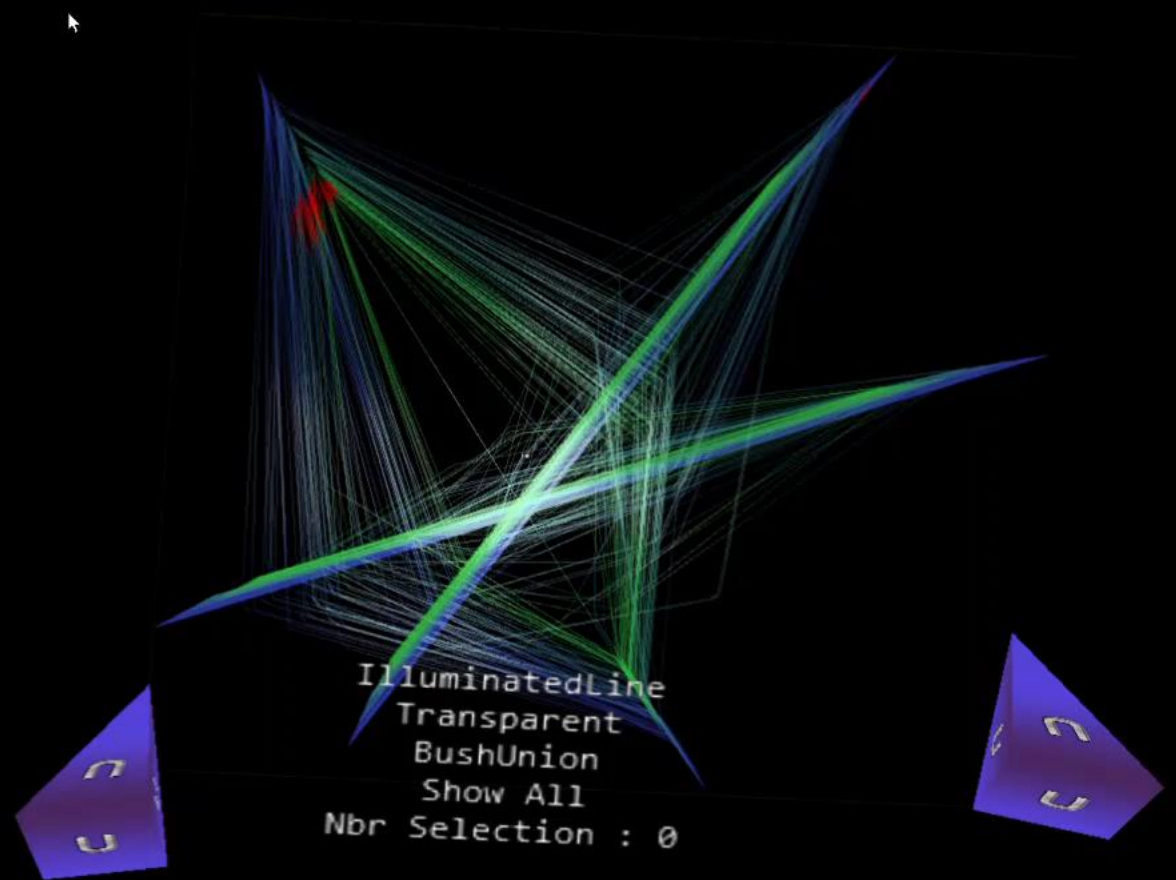


Hurter, C., Riche, N. H., Drucker, S. M., Cordeil, M., Alligier, R., & Vuillemot, R.
Fiberclay: Sculpting three dimensional trajectories to reveal structural insights.
IEEE TVCG 2019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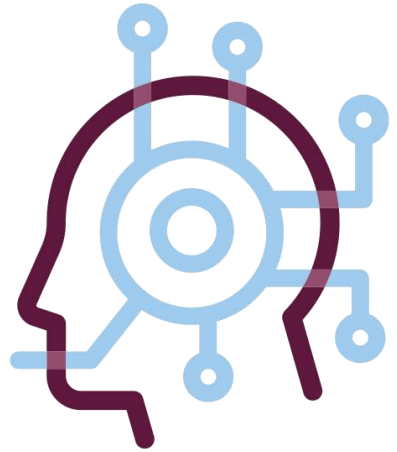
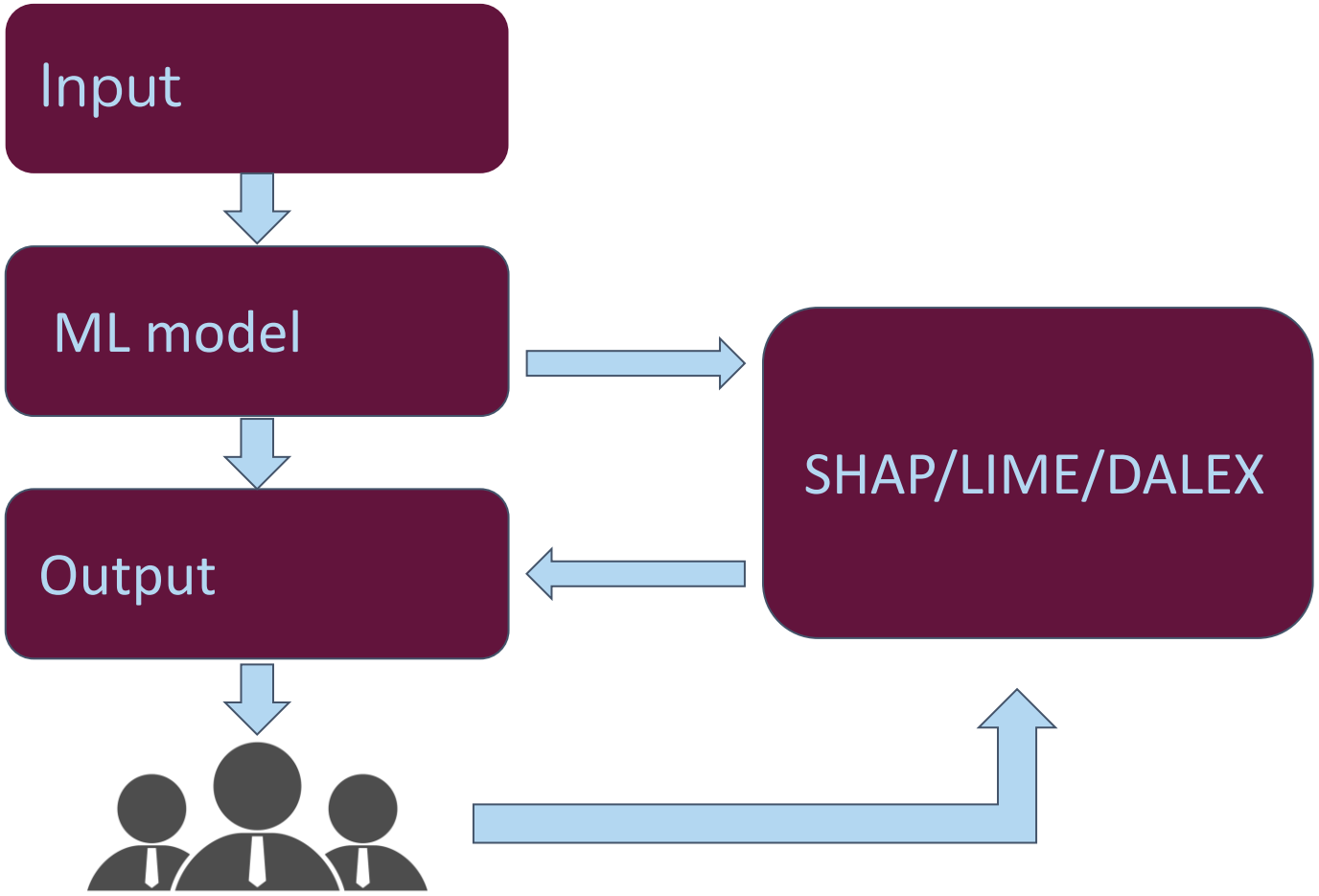
Delay Prediction



The underlying idea



SHAP: How much has each feature value contributed to the prediction compared to the average prediction?
The SHAP model provides explainability showing the parameters that best answer this question about a predicted delay

LIME: provides explanation by training surrogate models to approximate the predictions of the underlying black box model. It tests what happens to the predictions when variations of data is given into the machine learning model. LIME generates a new dataset consisting of permuted samples and the corresponding predictions of the black box model.

DALEX assumes that prediction is an approximation of the expected value of the dependent variable given values of different parameters. DALEX captures the contribution of a parameter to the model's prediction by computing the shift in the expected value of the prediction, while fixing the values of other parameters.

Thank You for Your Attention

For questions / more information:

christophe.hurter@enac.fr

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