



SUPPORTING
EUROPEAN
AVIATION

MUAC Contrail Trials

ML for contrail detection with ground
based cameras

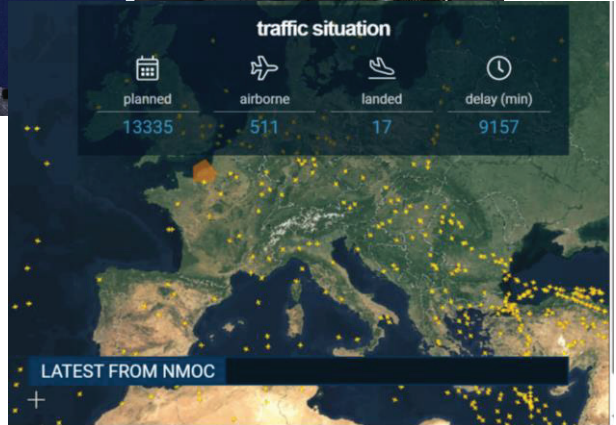
Dr. R. Ehrmantraut
Fly AI Forum
2025-04-22 Brussels



EUROCONTROL at a glance



- network coordination,
- capacity management,
- flow management
- airport integration
- crisis management
- CNS monitoring
- aviation spectrum



ACC - MUAC

MUAC controls more than **5,700** aircraft per day

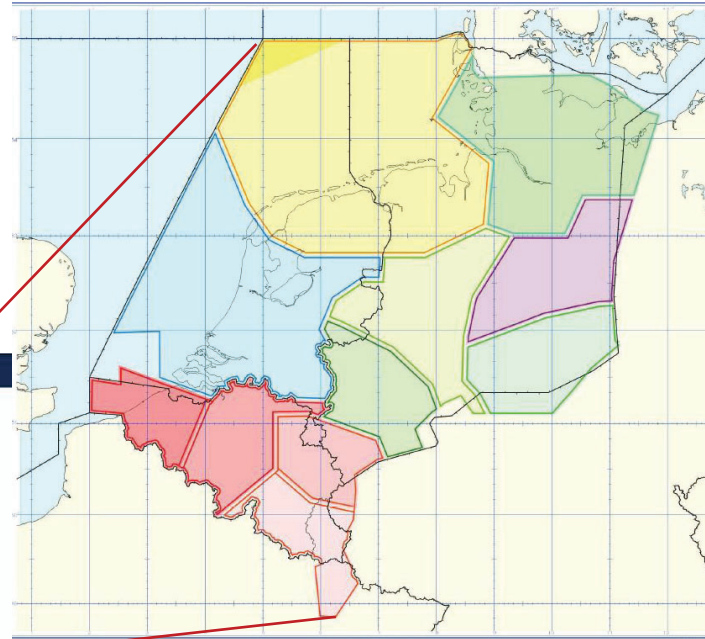
80% of MUAC's traffic is climbing and descending



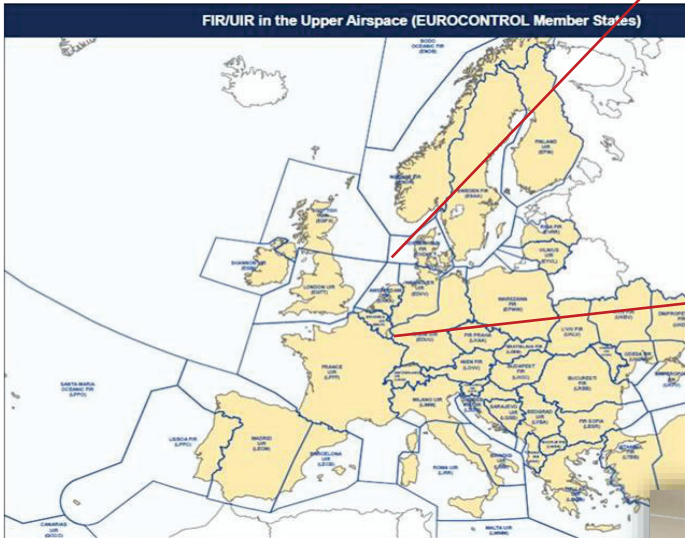
Maastricht Upper Area Control MUAC

MUAC controls more than **5,700** aircraft per day

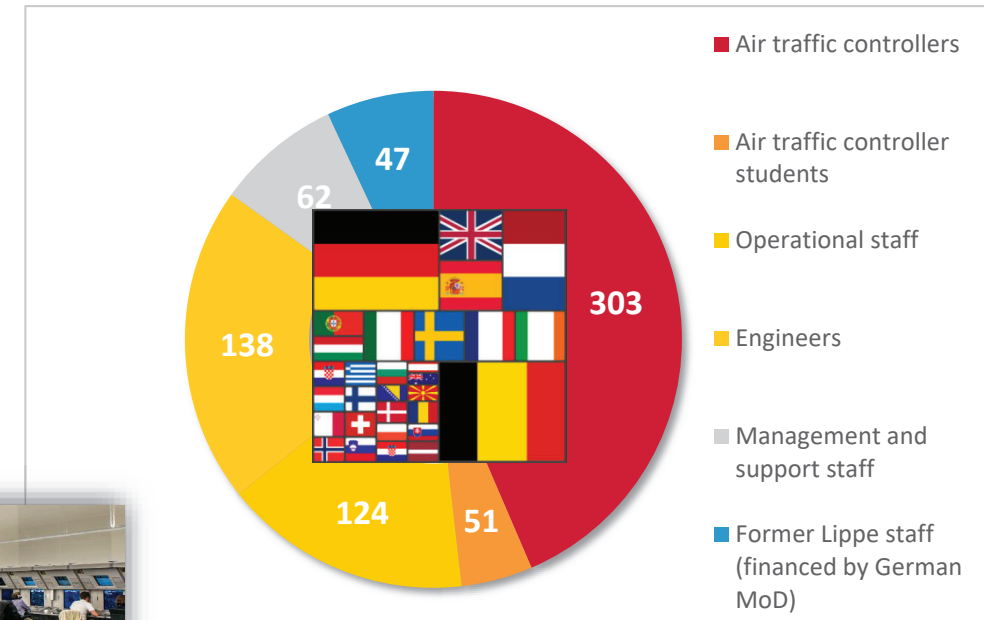
80% of MUAC's traffic is climbing and descending



The MUAC airspace covers **260.000** km² over Belgium, Luxembourg, the Netherlands and north-west Germany.

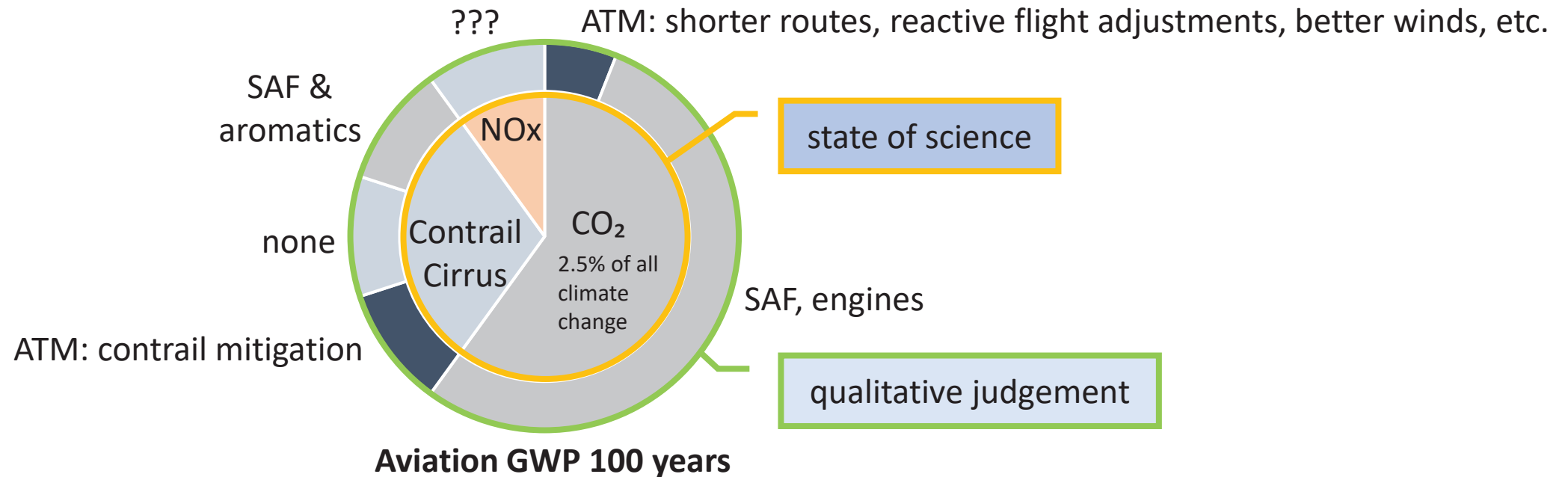


16% of all flights passing through Europe use MUAC's airspace.



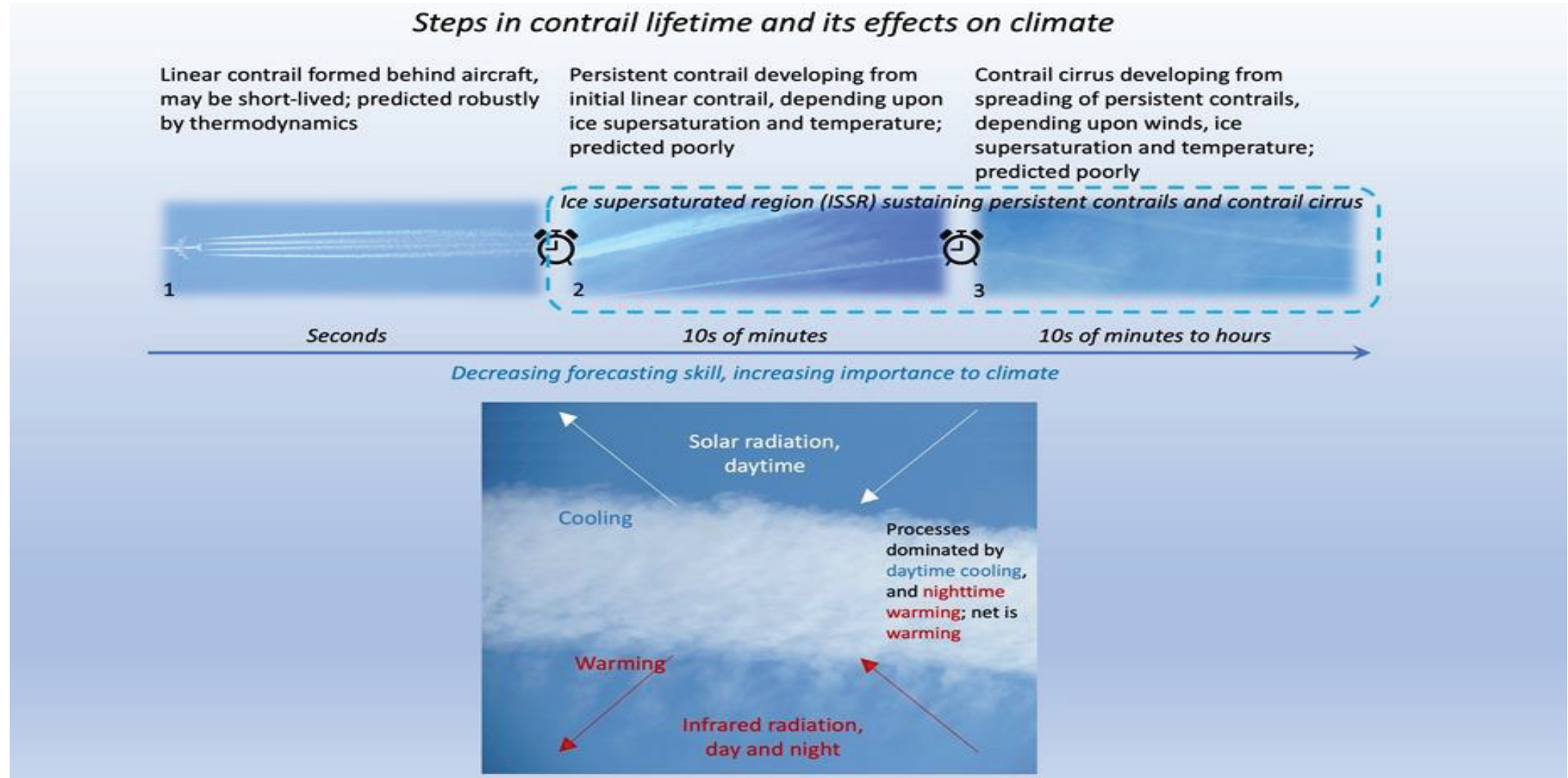
Aviation Global Warming Potential

mitigation contributors for GWP100 (estimates)



- ⇒ ATM important mitigator
- ⇒ non-CO₂ slice is big despite high scientific uncertainty
- ⇒ importance of trials

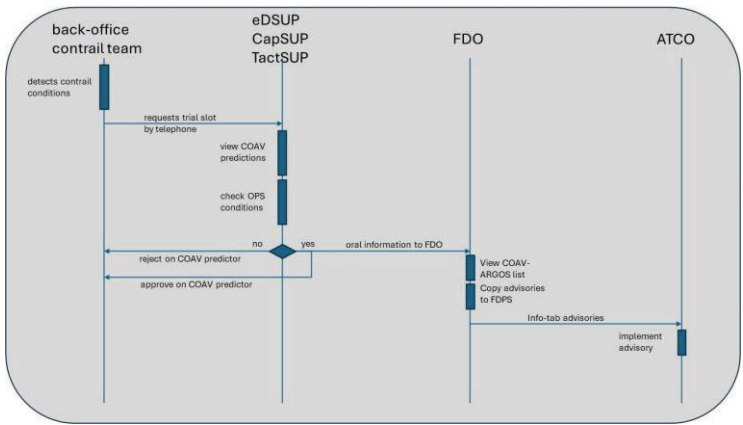
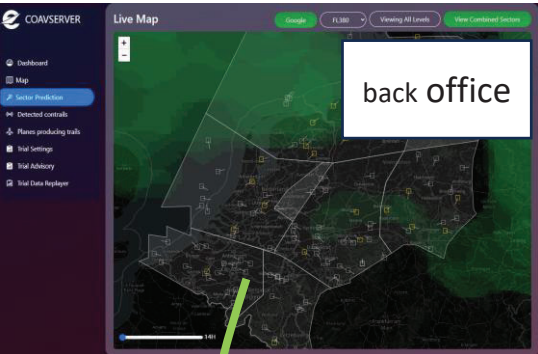
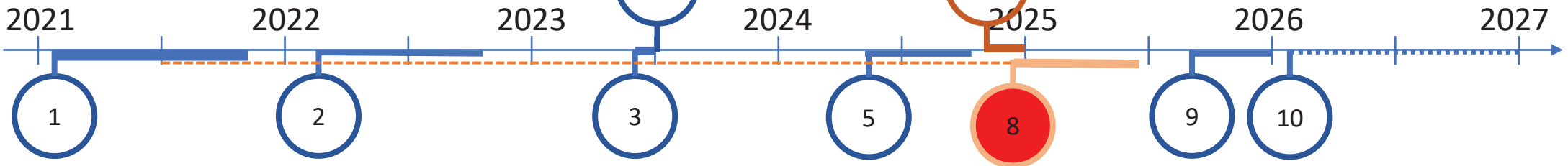
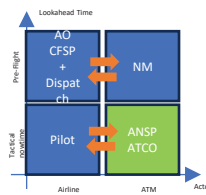
Climate Change, Non-CO₂, ISSR and Contrail Cirrus



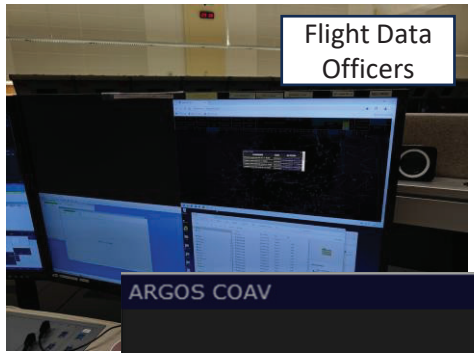
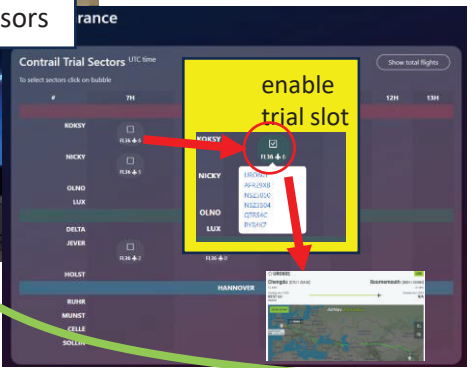
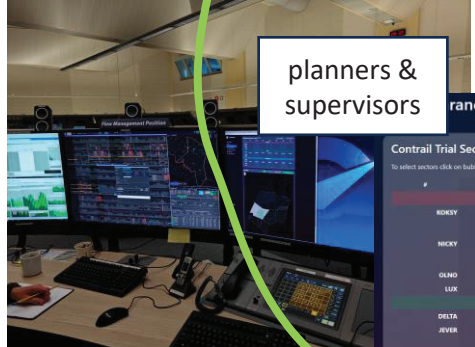
Shine, K. and D. Lee, 2021

MUAC Contrail Trials

2025 contrail trial with google



AFR33RL Contrail LUX-OLNO-RUHR-MUNST-SOLLIN-CELLE 36-37 to FL350



- trial setup not permitting to integrate deep into online ATCO radar screen
- work-around via FDO-ATCO system messages

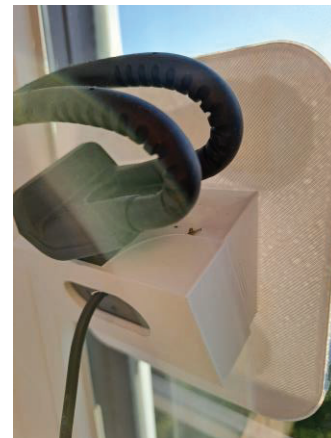
COMMAND	TIME
AFR54NN Contrail DELTA-JEVER 34-37 to FL390	14:50:37
AFR33RL Contrail LUX-OLNO-RUHR-MUNST-SOLLIN-CELLE 36-37 to FL350	14:47:21

MUAC Contrail Server

multi camera system



Contrail Avoidance Camera
Installation Preparation



Hardware quad camera

- cheap custom boxes in 3D print
- cheap commercial HD webcams
- raspberry pi
- **small distortions**

Hardware single camera with ADS-B

- cheap custom mount in 3D print
- behind window mount
- cheap commercial HD webcams
- raspberry pi

Hardware next camera with ADS-B

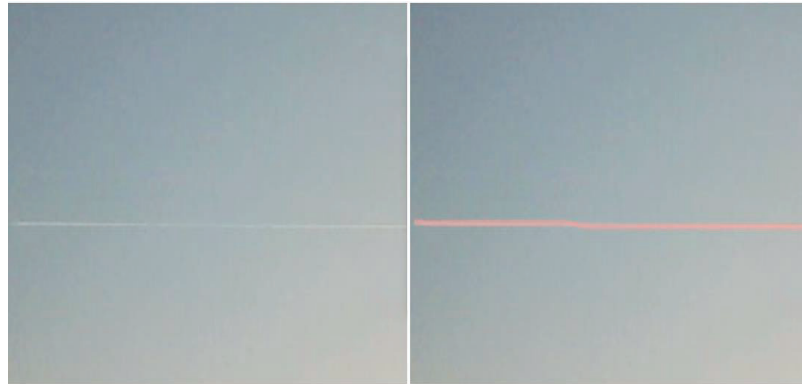
- night vision low price
- raspberry pi

Actual deployment

- quad at Kermt, MUAC, Oostende (TUI)
- single at Aachen

MUAC Contrail Server

contrail detection ML 2023



original image

labelling input



first promising result (video)

Contrail detection work in 2023 [1]

- labelling linear contrails
- fastAI library: very easy and fast results
- first promising results after only some hundreds labelled images

Architecture	Backbone	Train Loss	Validation Loss	Dice	Jaccard	Train Duration
U-NET	ResNet18	1.31×10^{-3}	1.55×10^{-3}	0.63	0.46	35:31:00
U-NET	ResNet34	1.28×10^{-3}	1.54×10^{-3}	0.63	0.46	38:13:00
HRNet	HRNet_w18	1.52×10^{-3}	1.81×10^{-3}	0.54	0.37	47:40:00

[1] 2023, Dimitri Croes, Contrail Avoidance - Detecting contrails and/or contrail prone areas, Fontys University of Applied Sciences

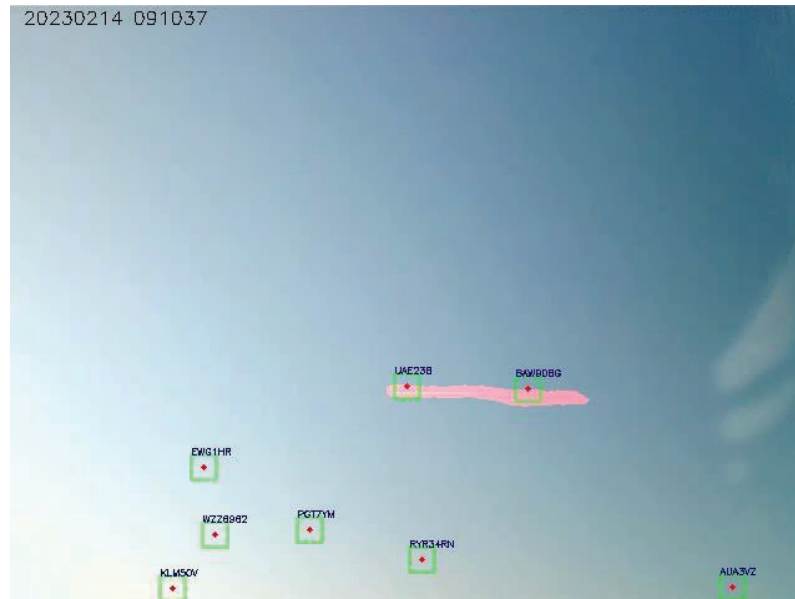


Dimitri Croes
bsc student 2023

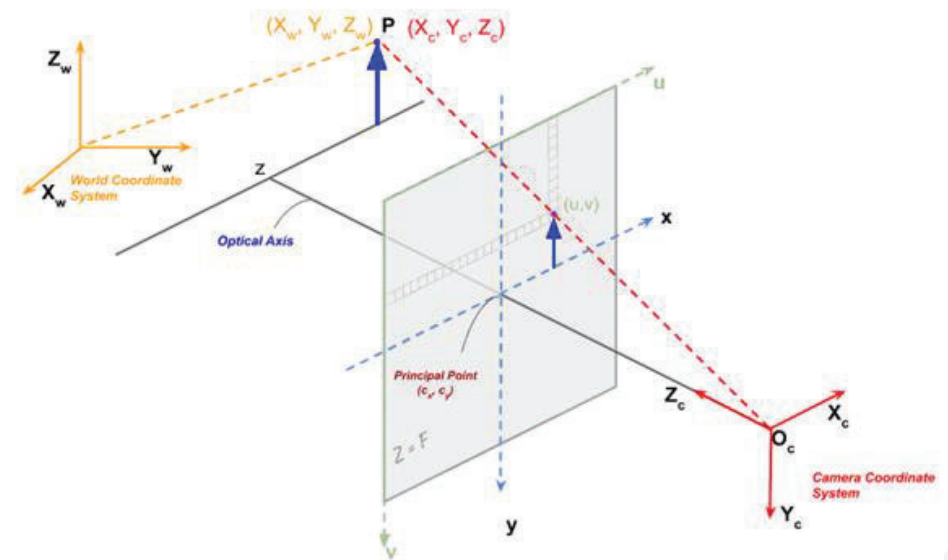
MUAC Contrail Server

computer vision for correlation with flight 2023

1. using computer vision (CV) to calibrate cameras
 2. use calibration of camera to project radar plot onto camera feed
 3. correlate projected flight with contrail detection
- Step 3 has never worked to full satisfaction and is currently under review



first promising result + flights (video)



MUAC Contrail Server

contrail detection ML 2024



Required improvements

1. contrail-to-flight correlation needs higher true-positive rates
2. unique identifier for contrails
3. evolution of contrails over time to assess their climate-criticality

New campaign for multi-contrail class categorisation

- Classification of short (yellow), thin (red), wide (green), and cirrus (blue)
- 5000+ images labelled
- 500+ for test

Results conclusive for classification and identification



ICNS 2025

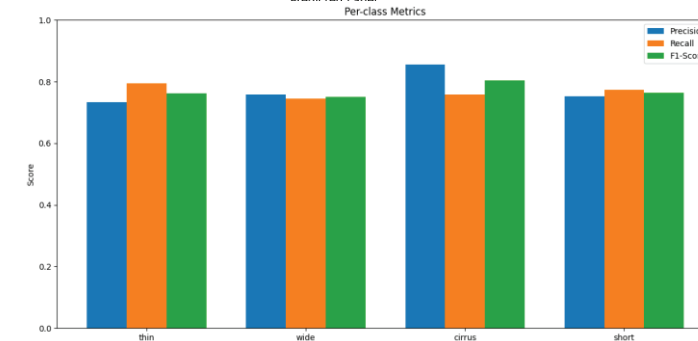
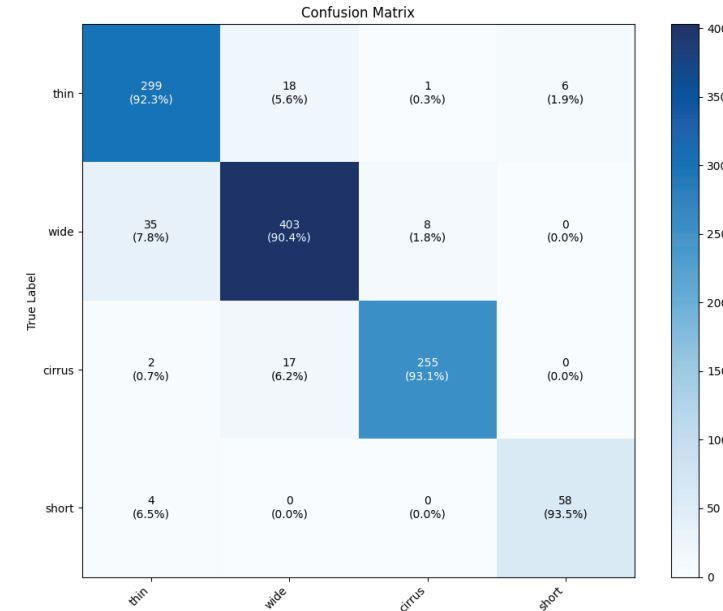
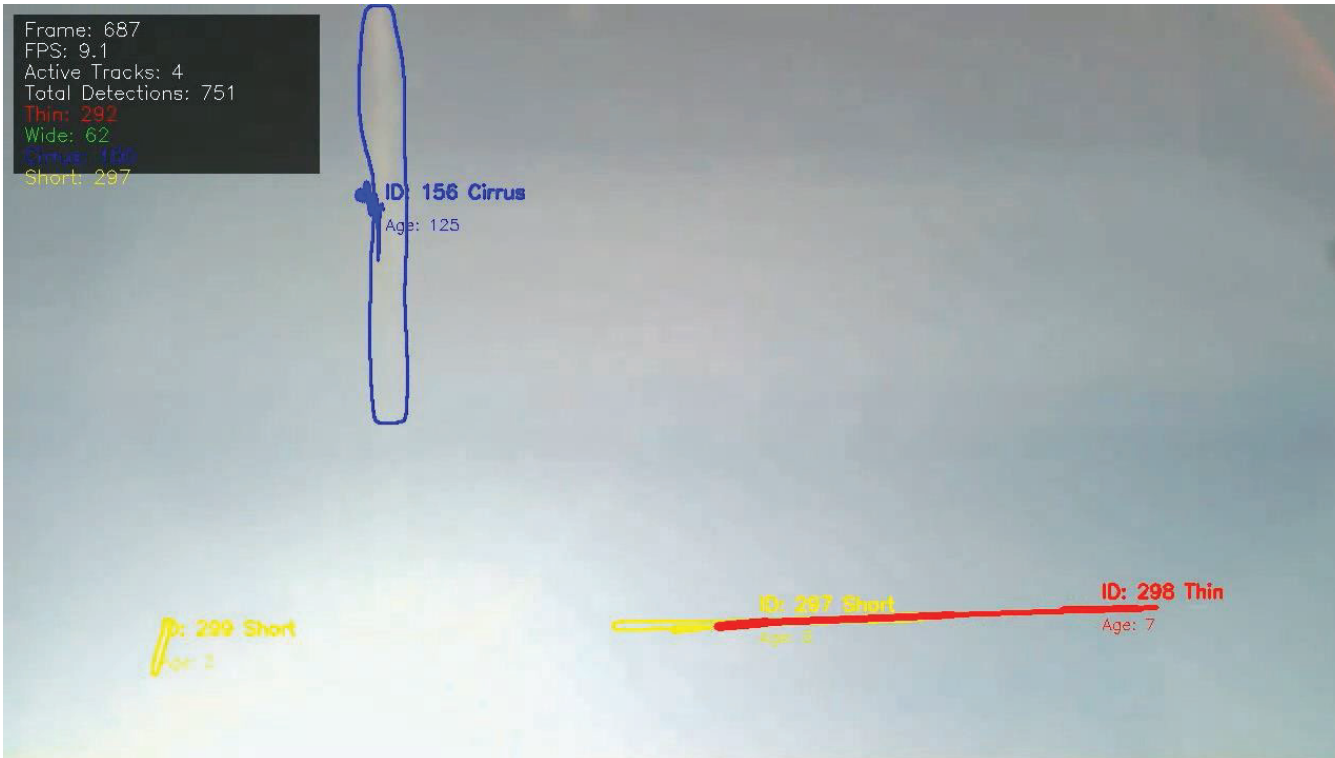


Jan Van Huffel
msc student 2024



MUAC Contrail Server

contrail detection and tracking ML 2025



Achilleas Leivadiotis
msc student 2025



PERFORMANCE
THROUGH
INNOVATION



related videos

<https://youtu.be/oz4OyEfrD4Q>
<https://youtu.be/r82fevDWtIM>
https://youtu.be/TyvNDWDg_KI



Thank you!

masuac.contrail@eurocontrol.int

Dr. Rüdiger Ehrmanntraut
senior project manager & exploration



Ilona Sitova
sustainability expert



Anja Burrige-Diesing
air traffic controller



Milena Bowman
manager airspace, systems & procedures



Vincent Taverniers
sustainability expert



Dimitri Croes
data science and software engineer



MUAC Contrail Server

real-time system to plan act evaluate

+5h contrail prediction

- DWD/D-KULT
- Google
- Pycontrail
- WIMCOT

