member of FABEC

EUROCONTROL

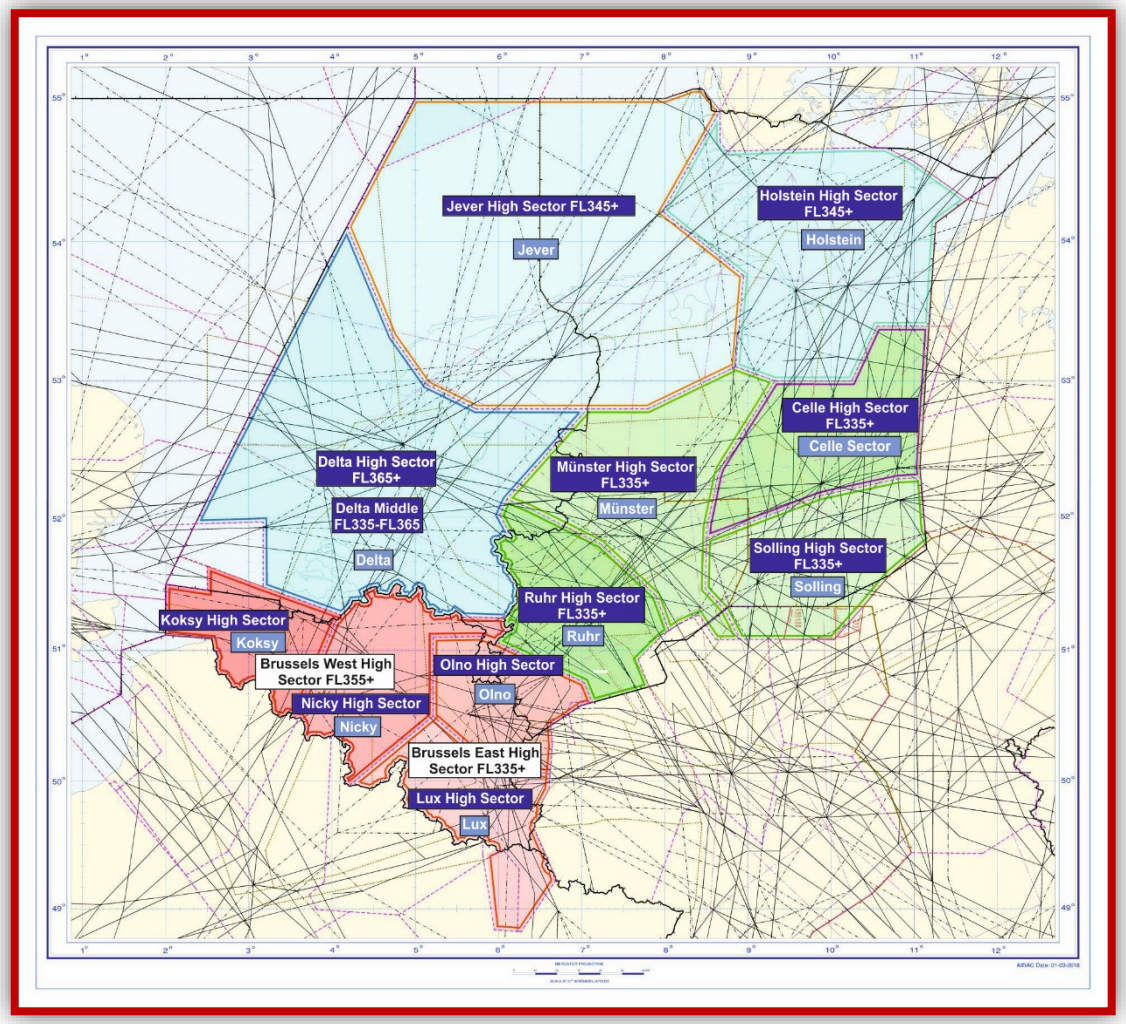
EUROCONTROL Maastricht Upper Area Control Centre
OPS & Automation Strategy

3 October 2019

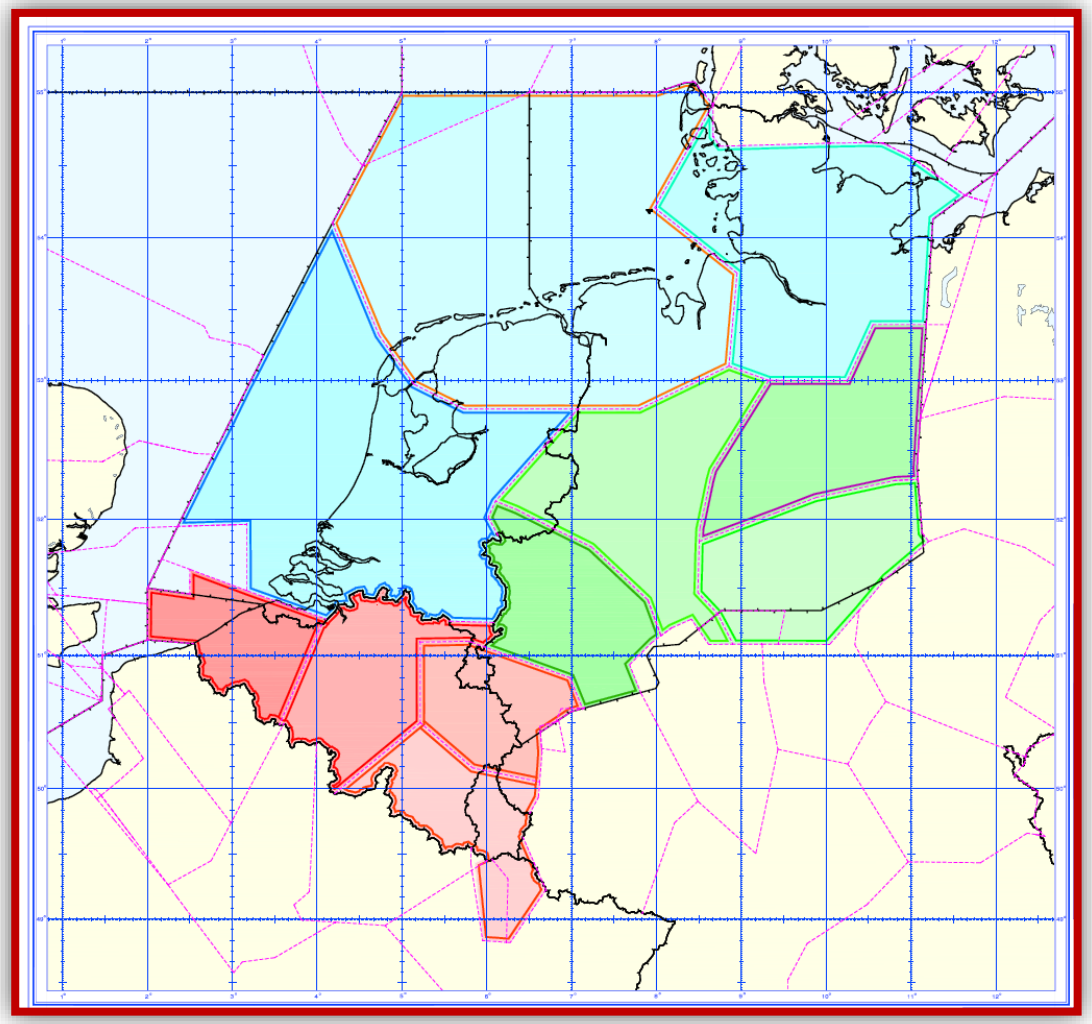
'Let ATCOs focus on the real, challenging work,
to do what they are the best at,
and leave the routine work to the machine.'

EUROCONTROL

Cross-border sectors



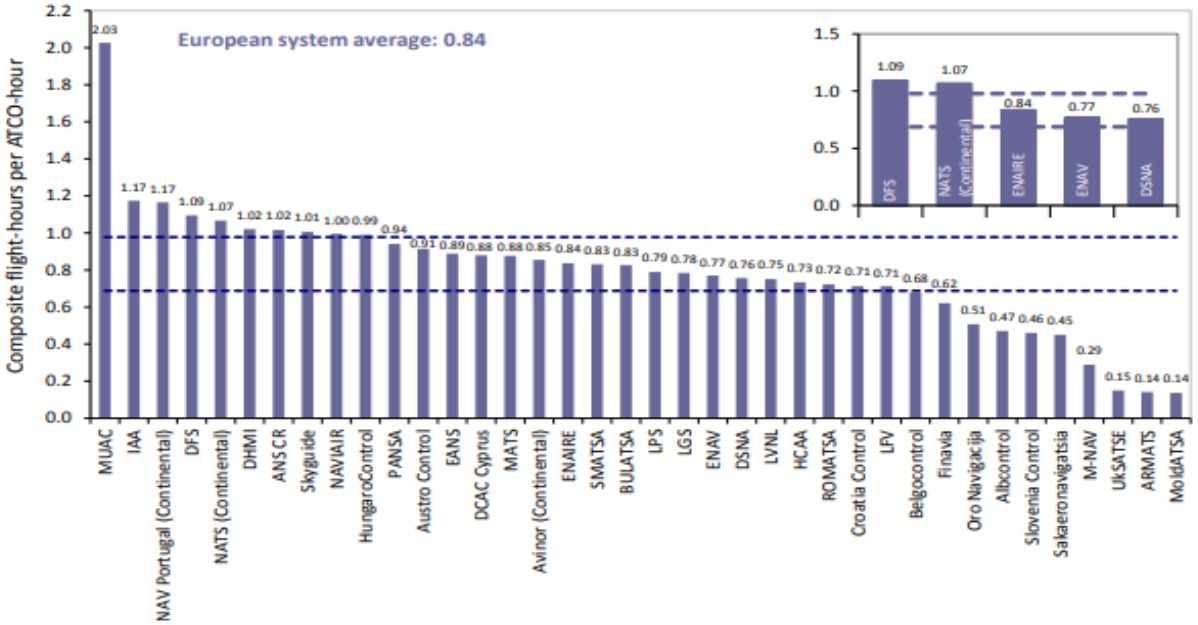
Functional boundaries



Some fast facts

- Real en-route cost per service unit has fallen by **17%** in real terms from 2012 to 2017
- **185 million** passengers are transported safely across MUAC airspace each year
- On busy days, MUAC controls up to **5,700** aircraft
- **80%** of MUAC's traffic is climbing and descending (not traffic purely on overflights)

MUAC Performance: Record productivity



- MUAC ATCO productivity is the highest in Europe
- Both ATCO and sector productivities are at a **record high** at MUAC

Automation Strategy: Vision & Objectives

‘Let ATCOs focus on the real, challenging work,
to do what they are the best at,
and leave the routine work to the machine.’

The study into automation (2017)

Findings:

- no systematic System but product development
- no dedicated focus on automation
  - the further we automate the more challenges arise
- myth? piecemeal automation → full automation

Level of Automation Taxonomy (amended; based on SESAR Report)

		INFORMATION			ACTION
		Perception	Analysis	Decision	Execution
LEVEL OF AUTOMATION	low	manual	working-memory-based	human	manual
		artefact-supported	artefact-supported	artefact-supported	artefact-supported
		low-level automation	low-level automation	automated support	step-by-step support
		medium-level automation	medium-level automation	rigid automated support	low-level support
		high-level automation	high-level automation	low-level automation	high-level support
		full automation	full automation	high-level automation	low-level automation
	high			full automation	medium-level automation
					high-level automation
					full automation

Level of Automation at MUAC (2018)

A1 – artefact-supported

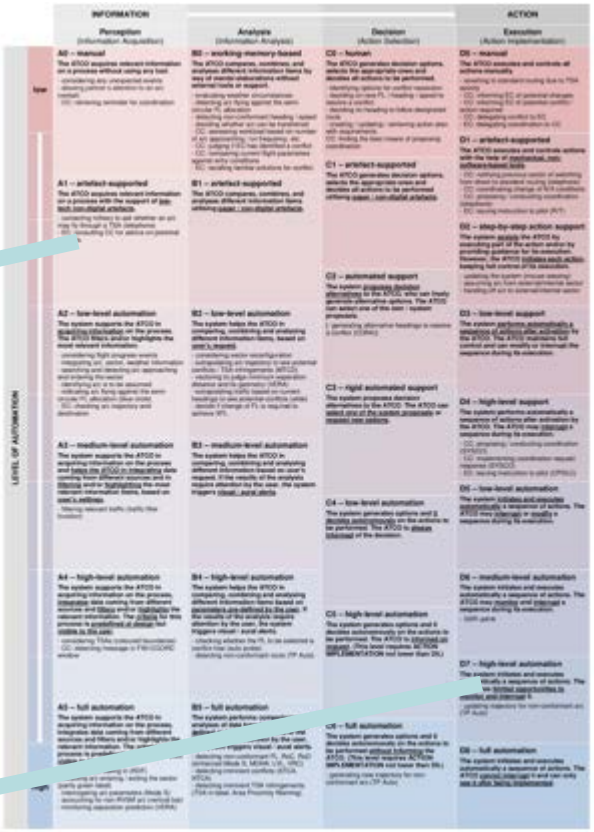
The ATCO acquires relevant information on a process with the support of low-tech non-digital artefacts.

- contacting military to ask whether an a/c may fly through a TSA (telephone)
- EC: consulting CC for advice on potential conflicts

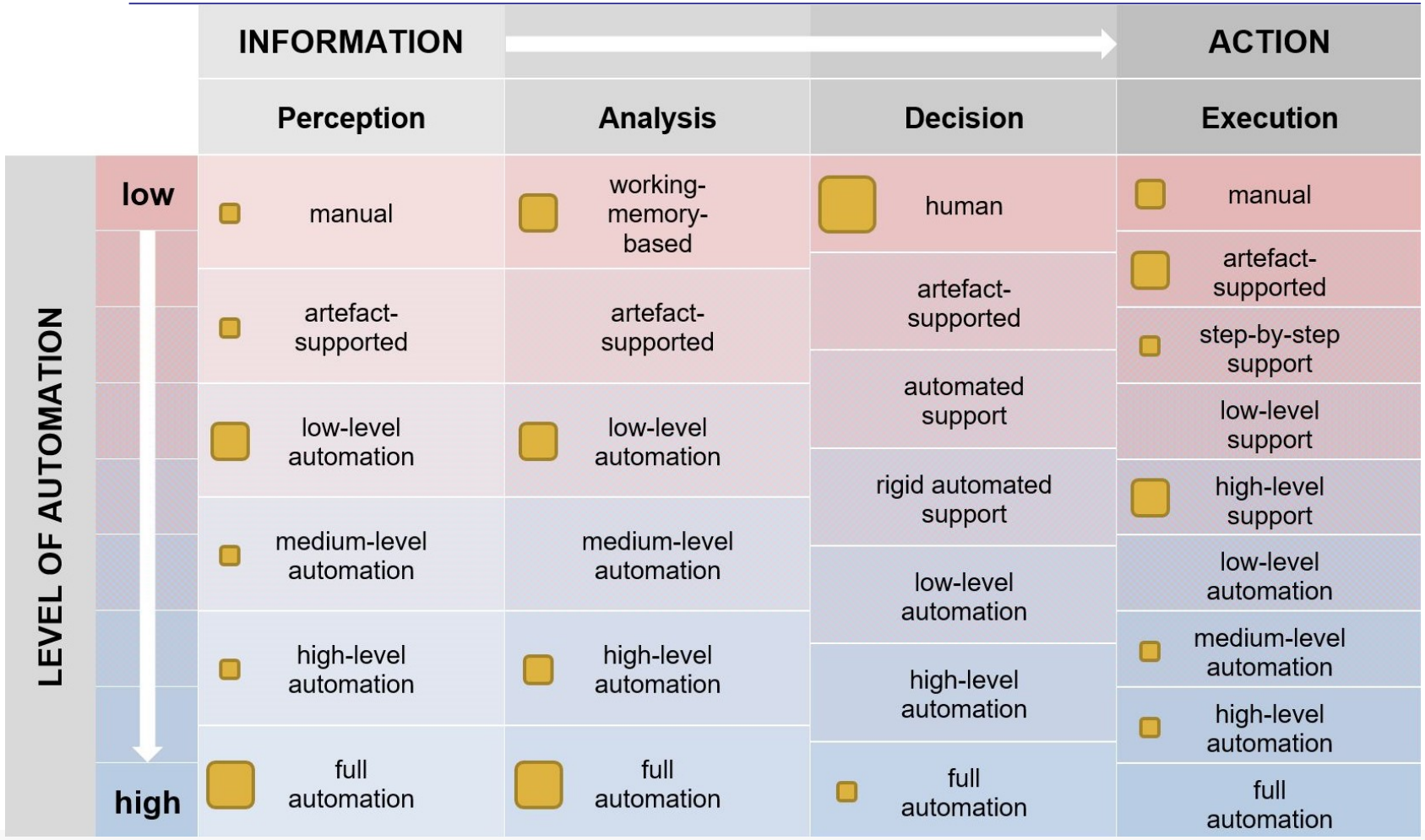
D7 – high-level automation

The system initiates and executes automatically a sequence of actions. The ATCO has limited opportunities to monitor and interrupt it.

- updating trajectory for non-conformant a/c (TP Auto)



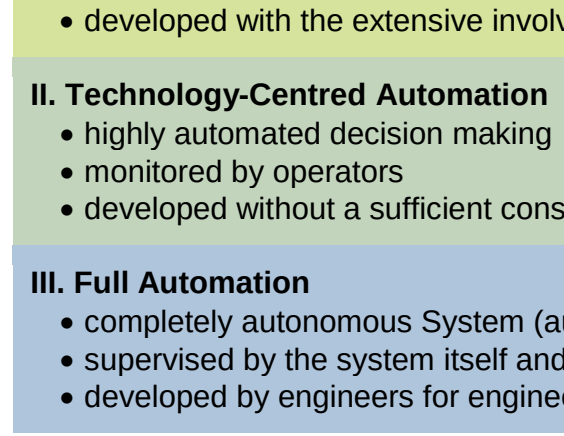
Level of Automation at MUAC (2018)



: current tasks

Paths to Full Automation

Stage	Path A	Path B
I. Human-Centred Automation • human decision making accelerated by automated tools • moderately automated, cooperative System • developed with the extensive involvement of end users		
II. Technology-Centred Automation • highly automated decision making • monitored by operators • developed without a sufficient consideration of operator needs		
III. Full Automation • completely autonomous System (automated decision making) • supervised by the system itself and a few system engineers • developed by engineers for engineers		



TESLA

Path A:
The gradual allocation of more and more functions to automation in all environments – which renders Stage II inevitable.

Path B:
Stage II is circumvented
by the early implementation of full automation
in a constrained environment
which is then gradually expanded

WAYMO

Layers in the MUAC Automation Strategy

Vision

MUAC aims for a paradigm shift (Path B) in automation in all areas to manage future demands by improving capacity and productivity, assuring safety, and keeping staff engaged in critical decision making.

Objectives

Obj1 Fully automated pre-tactical phase

Obj2 Automated decision making and execution support for complex tactical scenarios

Obj3 Fully automated separation assurance in the basic tactical scenarios

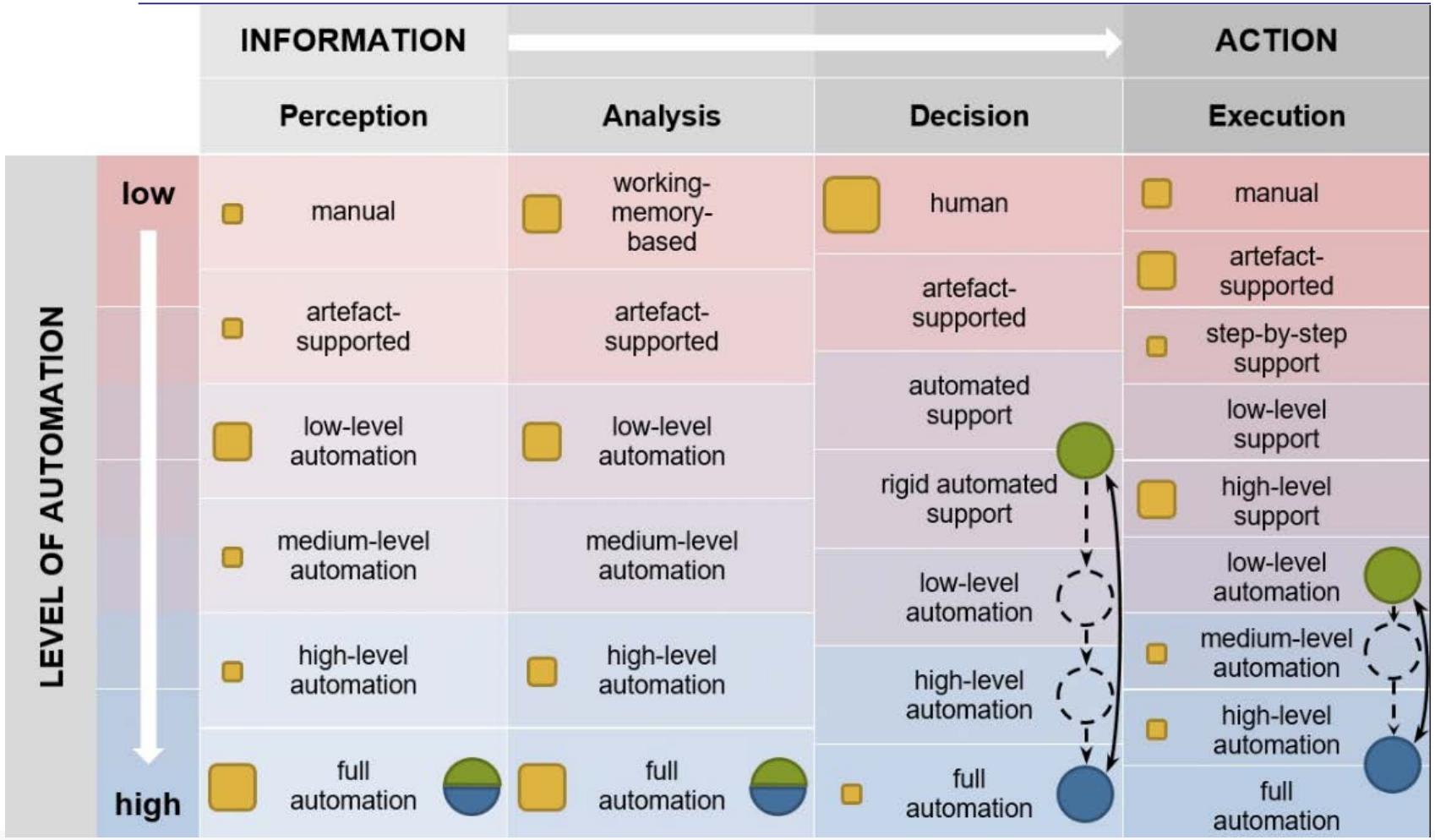
+ Automation Principles

+ Design Principles

Implem.

A2A (TPI), FLOGOS, BvsC, ARGOS

MUAC LoAT & Automation Ambitions



: current tasks

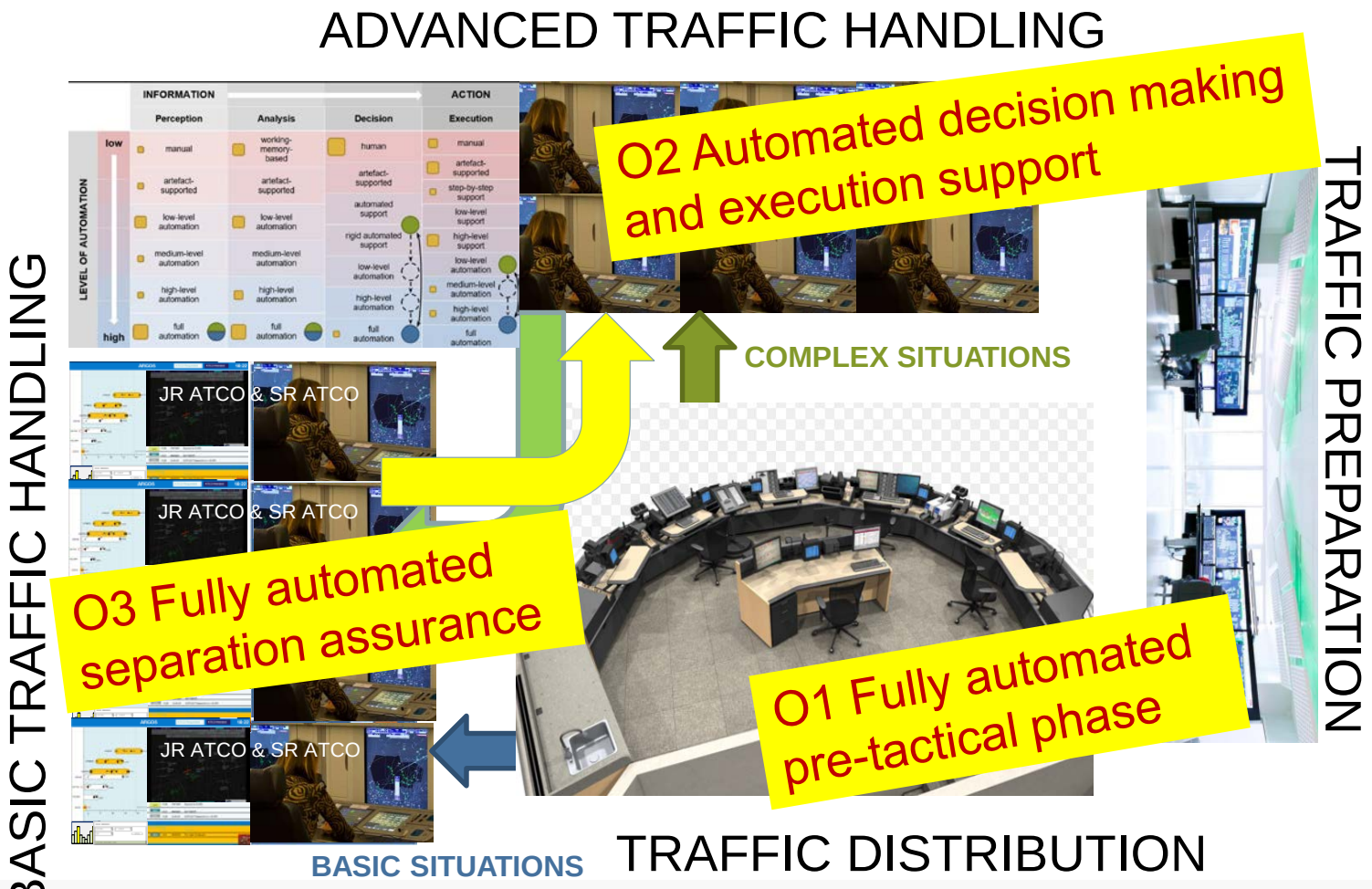
: complex scenarios

: basic scenarios

– – : Path A

—— : Path B (chosen)

ConOPS 12 December 2028



Automation Strategy: Implementation

‘Let ATCOs focus on the real, challenging work,
to do what they are the best at,
and leave the routine work to the machine.’

Main ongoing activities

O1: Fully automated pre-tactical phase

- CSS Task Analysis ➔ ATFCM/ACM Roadmap (including TPI)
- FLOGOS ➔ Augment ATFCM through ML technics (CfT to be launched)

O2: Automated decision making and execution support for complex traffic

O3: Fully automated separation assurance in the basic traffic

- BvsC study: What is basic traffic and what is not?
- Experimental implementation: ARGOS

Experimental ARGOS

Spark: Build a system so that I can do ATC at night (01:00-03:00)

Goal: Fully automated ATC System in perfect environment, basic traffic

Idea: Automate basic, and find ways to support ATCOs in complex traffic

- DCT to Exit Point
- Climb to TFL ASAP – DESCEND to TFL ALAP
- MUST BE Conflict free (0 = 5, 1 = 5.5, 8 = 6.5)

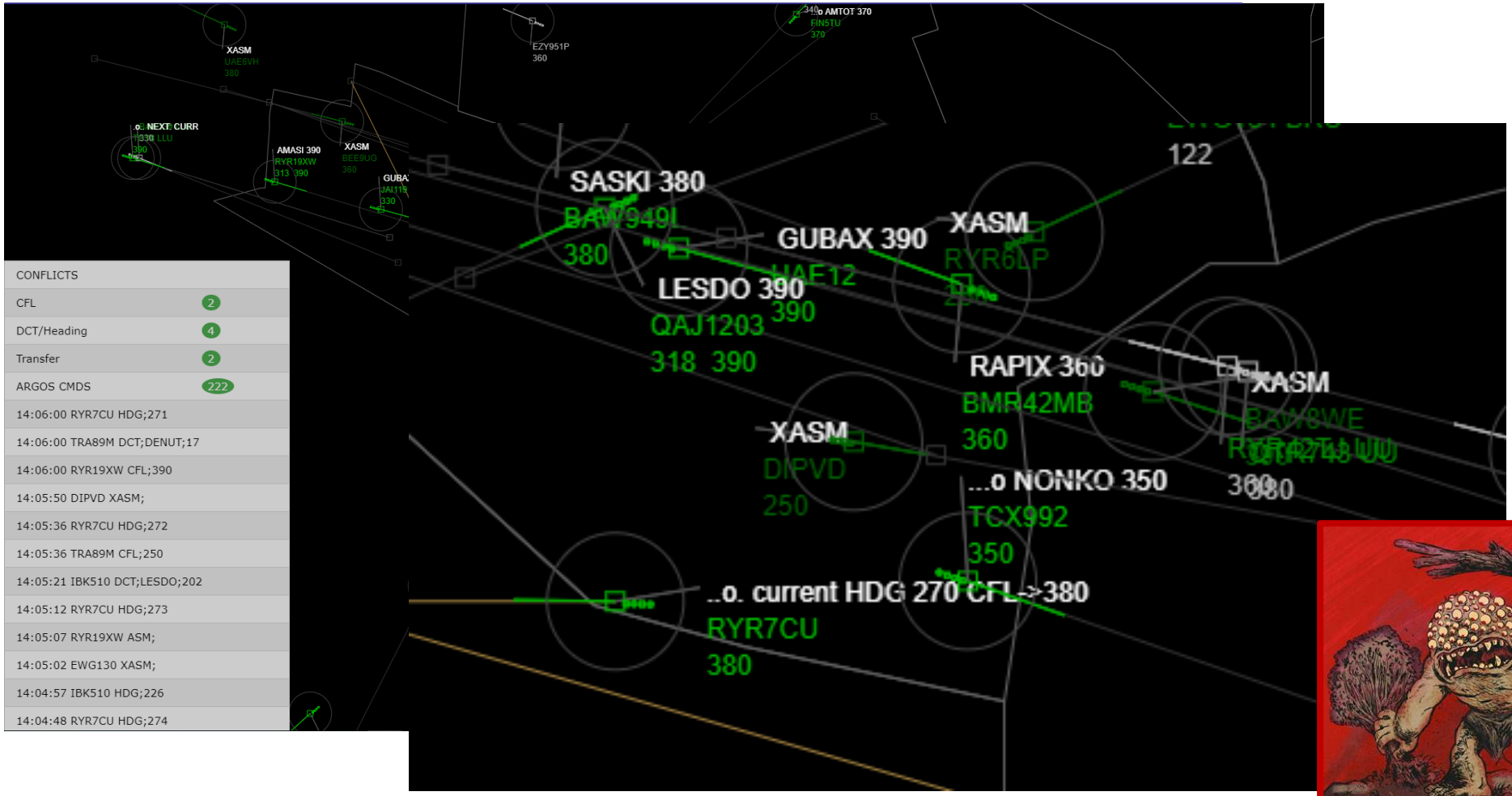
- Sequencing at exit
- Stay in sector
- Must climb/descend
- Variable look-ahead-time

Stability

Auto ATCO / Auto Pilot Mode
(with random delay)

WIP: Semi-AUTO ATCO

ARGOS v0.1

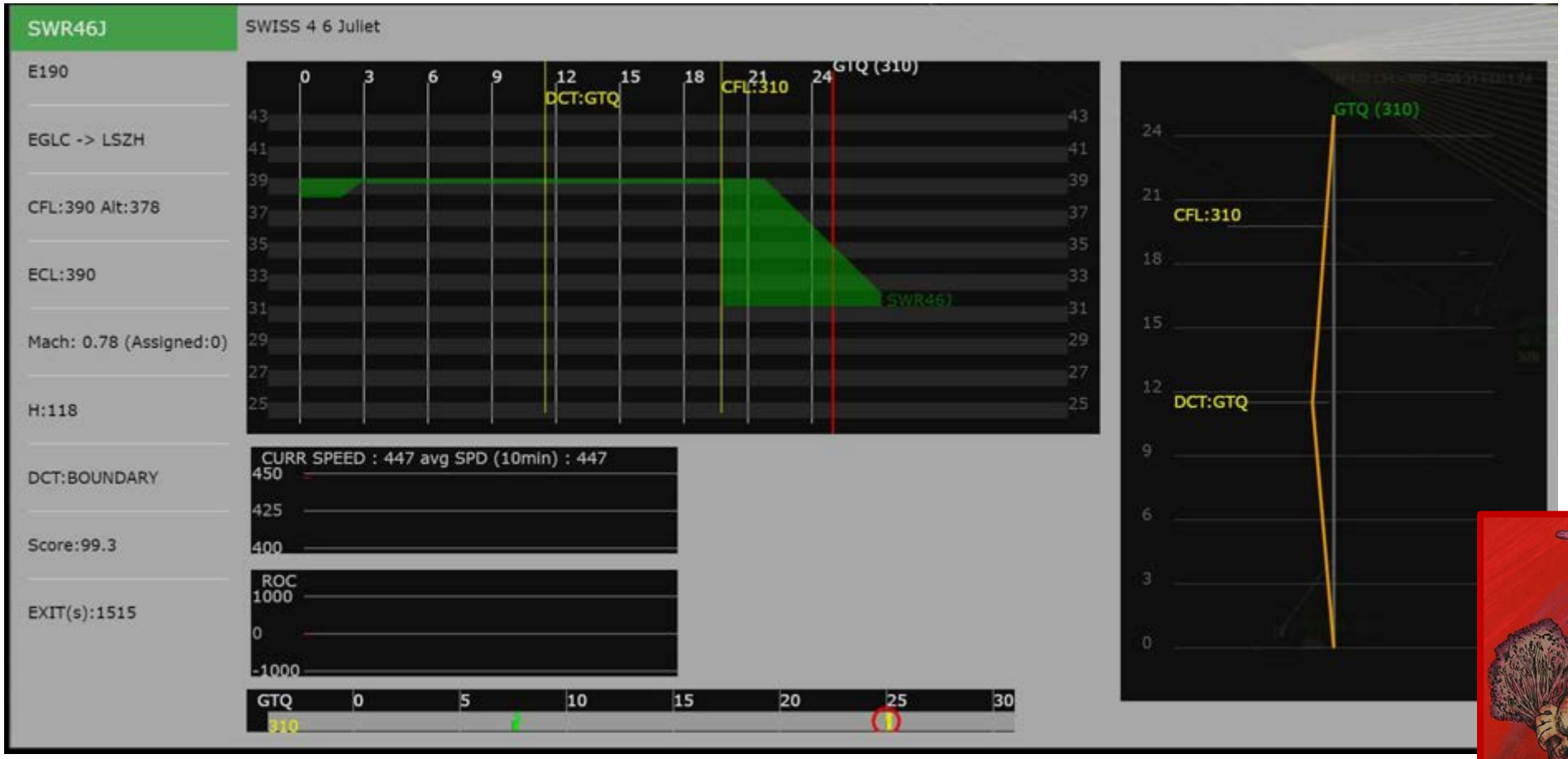

XASM
EZY951P
360
AMTOT 370
FIN5TU
370
NEXT CURR
AMASI 390
RYR19XW
313 390
XASM
BEE9UG
360
SASKI 380
380
GUBAX 390
XASM
RYR6LP
LESDO 390
390
QAJ1203
318 390
122
RAPIX 360
BMR42MB
360
XASM
DIPVD
250
...o NONKO 350
TCX992
350
..o. current HDG 270 CFL->380
RYR7CU
380
CONFLICTS
CFL 2
DCT/Heading 4
Transfer 2
ARGOS CMDS 222
14:06:00 RYR7CU HDG;271
14:06:00 TRA89M DCT;DENUT;17
14:06:00 RYR19XW CFL;390
14:05:50 DIPVD XASM;
14:05:36 RYR7CU HDG;272
14:05:36 TRA89M CFL;250
14:05:21 IBK510 DCT;LESDO;202
14:05:12 RYR7CU HDG;273
14:05:07 RYR19XW ASM;
14:05:02 EWG130 XASM;
14:04:57 IBK510 HDG;226
14:04:48 RYR7CU HDG;274

ARGOS v0.2

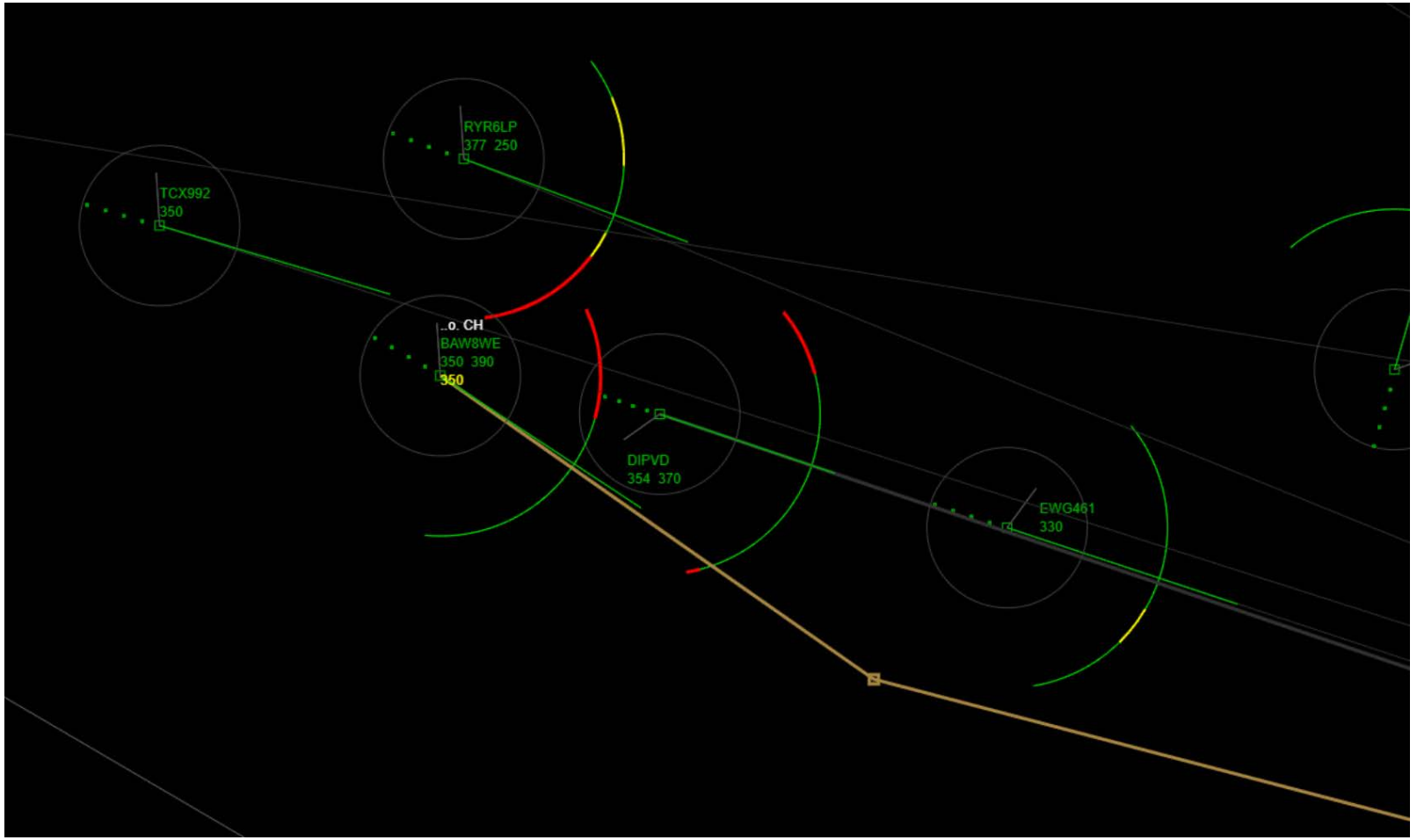
ARGOS has to answer following questions:

1. Why on HDG instead of DCT to Exit?
2. Why not climbing/descending to my TFL yet?
3. Why are we climbing/descending already?
4. What are the assumptions made when picking the solution (e.g. RoC)?
5. Are any two selected flights conflict-free?
6. When is a flight going to be transferred?
7. What is the sequence at XCOP?
8. Before entering AoR, what is a possible plan?

ARGOS v0.2 elements: Answers Window



ARGOS v0.2 elements: The ARCs



ARGOS Levels of Automation

ARGOS LoA	Description	LoA Decision	LoA Execution
L0	ARGOS does nothing	C0	D0
L1	Upon ATCO request for individual flight(s), ARGOS will suggest actions to the ATCO. ATCO executes own decisions.		
L2	For all flights, ARGOS suggests actions to ATCO. ATCO executes own decisions.		
L3	For all flights, ARGOS suggests actions to ATCO. ATCO executes own decisions, but ARGOS suggestion is default selection in menu.	C3	D5
L4	ARGOS suggests plan for each flight (a set of multiple timed actions). ATCO decides to let ARGOS handle individual flights and controls other flights.		
L5	ARGOS manages certain flights (for each flight, plan is presented and executed). ATCO monitors and can take flights away from ARGOS. ATCO controls non-ARGOS flights.		
L6	ARGOS manages all flights (for each flight, plan is presented and executed). ATCO monitors and can switch ARGOS off. ATCO controls flights when ARGOS is off.		
L7	ARGOS manages all flights (for each flight, plan is presented and executed). ATCO monitors and can take flights away from ARGOS. ATCO controls flights that s/he has taken away.		
L8	ARGOS manages all flights (for each flight, plan is presented and executed). ATCO is alerted by ARGOS when monitoring is required, that is, when ARGOS can still manage the situation but outside its comfort zone (i.e. with a reduced conflict free look-ahead time). ATCO can monitor as requested or take flights away from ARGOS (hence degrade the LoA to L5).	C5/6	D7/8
L9	ARGOS manages all flights.	C6	D8

ARGOS as Human-Centric Automation

	Task allocation	Logic	Interface
Automation Objective 2: decision-making support at complex traffic	**human-centric** ✓ ATCO is fully in the loop i.e. aware of all decisions & actions ✓ ATCO is not coerced into a monitoring role	**human-centric** ✓ ATCO takes all decisions & actions ✓ ATCO has the freedom to exercise own work style	**human-centric** ✓ ATCO involvement in development (e.g. SMART) ✓ HF principles applied (e.g. MUAC Design Principles, EID)
Automation Objective 3: fully automated control of basic traffic	**moderately human-centric** × ATCO is barely in the loop i.e. not aware of all decisions & actions ✓ ATCO is not coerced into a monitoring role	**moderately human-centric** ✓ ARGOS takes ATCO-conform decisions & actions × ARGOS is not meant to adapt to individual work styles	**human-centric** ✓ ATCO involvement in development (e.g. SMART) ✓ HF principles applied (e.g. MUAC Design Principles, EID)

By the MUAC Automation Objectives we claim that:

1. The Executive Controller does not need to be in the loop at each and every aircraft at all times (already happens today)
2. ARGOS will be able to get him/her back in the loop if necessary

ARGOS Level 8

L8	ARGOS manages all flights (for each flight, plan is presented and executed). ATCO is alerted by ARGOS when monitoring is required, that is, when ARGOS can still manage the situation but outside its comfort zone (i.e. with a reduced conflict free look-ahead time). ATCO can monitor as requested or take flights away from ARGOS (hence degrade the LoA to L5).	C5/6	D7/8

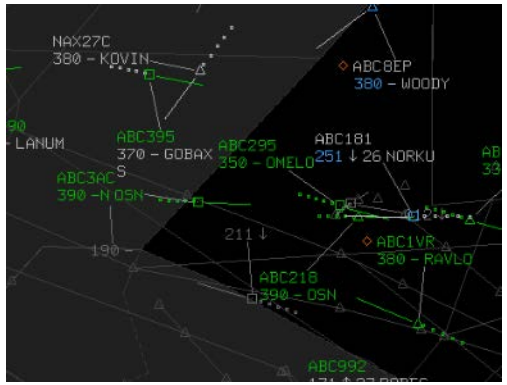
To be assessed

- ICAO regulations
- legality
- liability
- oversight
- certification

SESAR
HUCAN

Basic vs Complex study

- Experiment



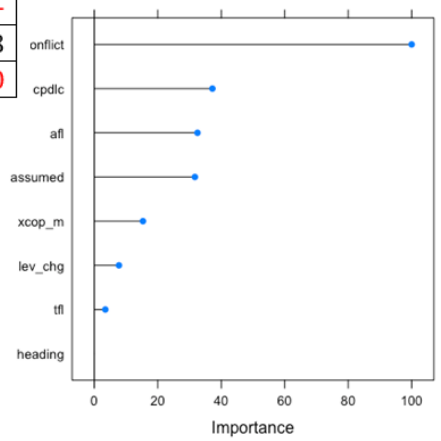
HANNOVER

As the EC of this sector, which aircraft would you feel comfortable with being handled by the CC?

	CC (1)	? (2)	EC (3)
consensus (100%)	28	65	12
qualified majority (67%)	52	29	24
simple majority (51%)	58	8	39

- Machine learned Model
  - When is a flight “basic“?
  - What are the contributing factors?

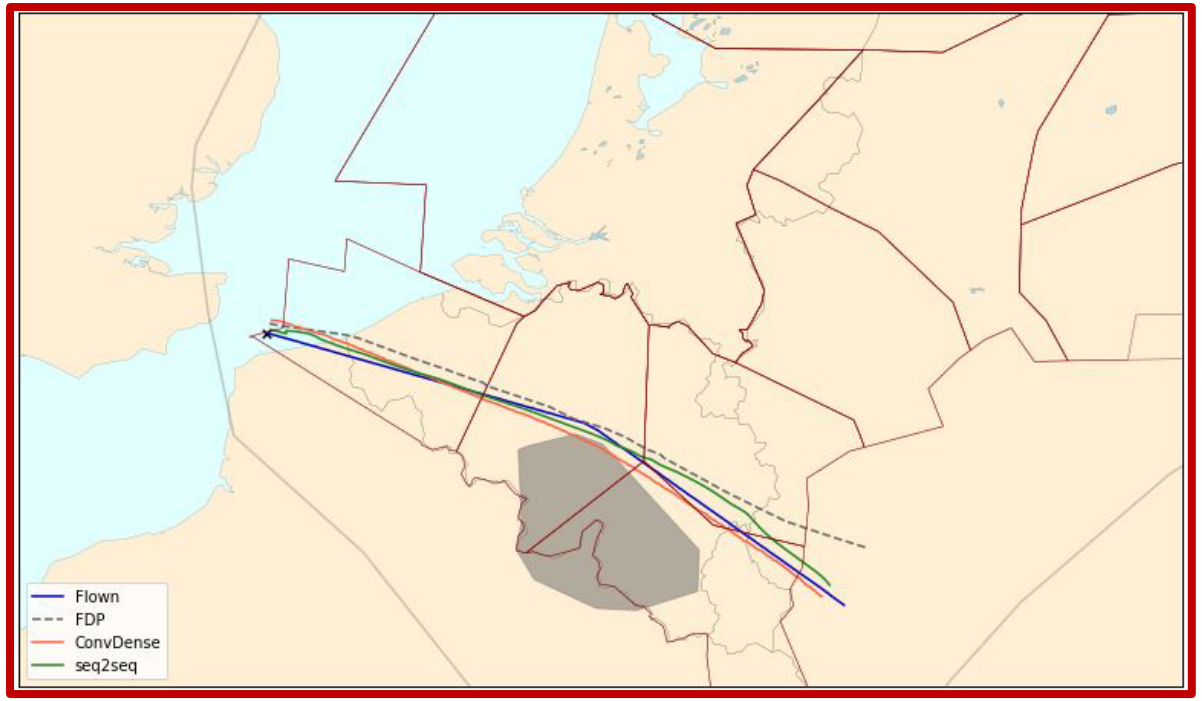
Consensus: CC (1) vs ? (2) + EC (3)			
	bal. acc.	sens.	ppv
logreg	0,7378	0,5556	0,7143
fuzzy	0,7733	0,6667	0,6667
boosted tree	0,8689	0,7778	0,8750
random forest	0,7933	0,6667	0,7500
naïve bayes	0,6111	0,2222	1,0000
LVQ	0,5000	0,0000	-
svm radial	0,5000	0,0000	-
svm linear	0,8489	0,7778	0,7778
svm polynomial	0,5556	0,1111	1,0000

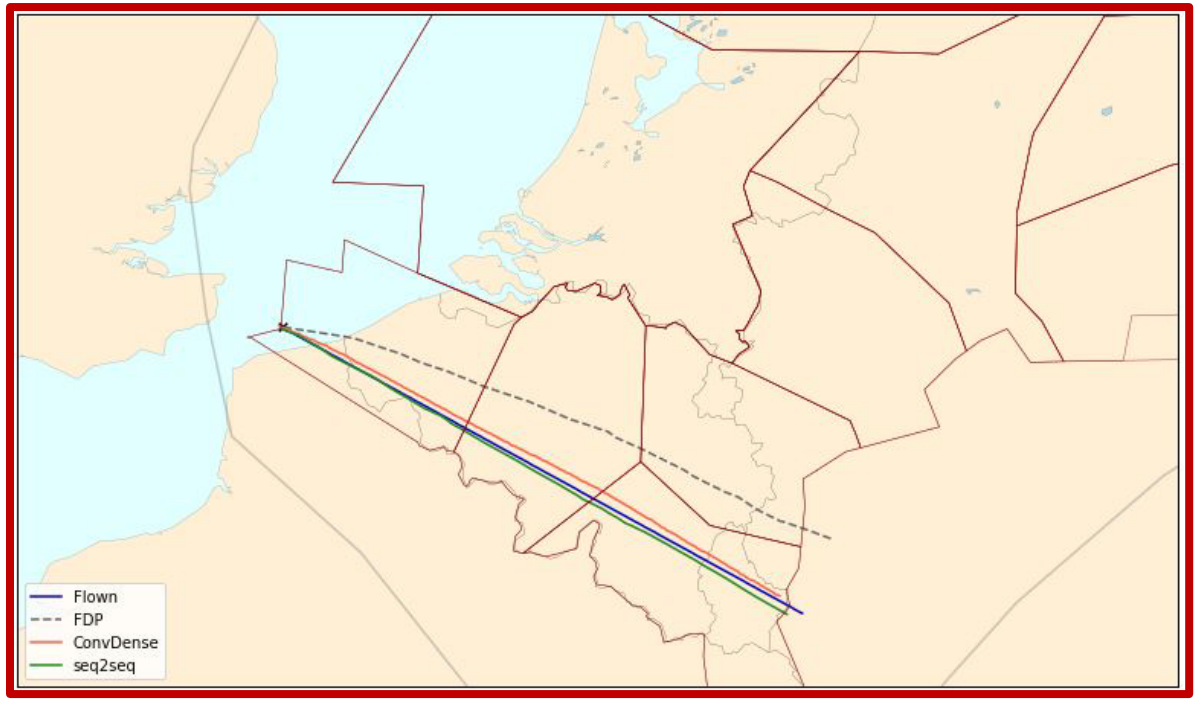


- First results available
  - Model to be further trained and tested

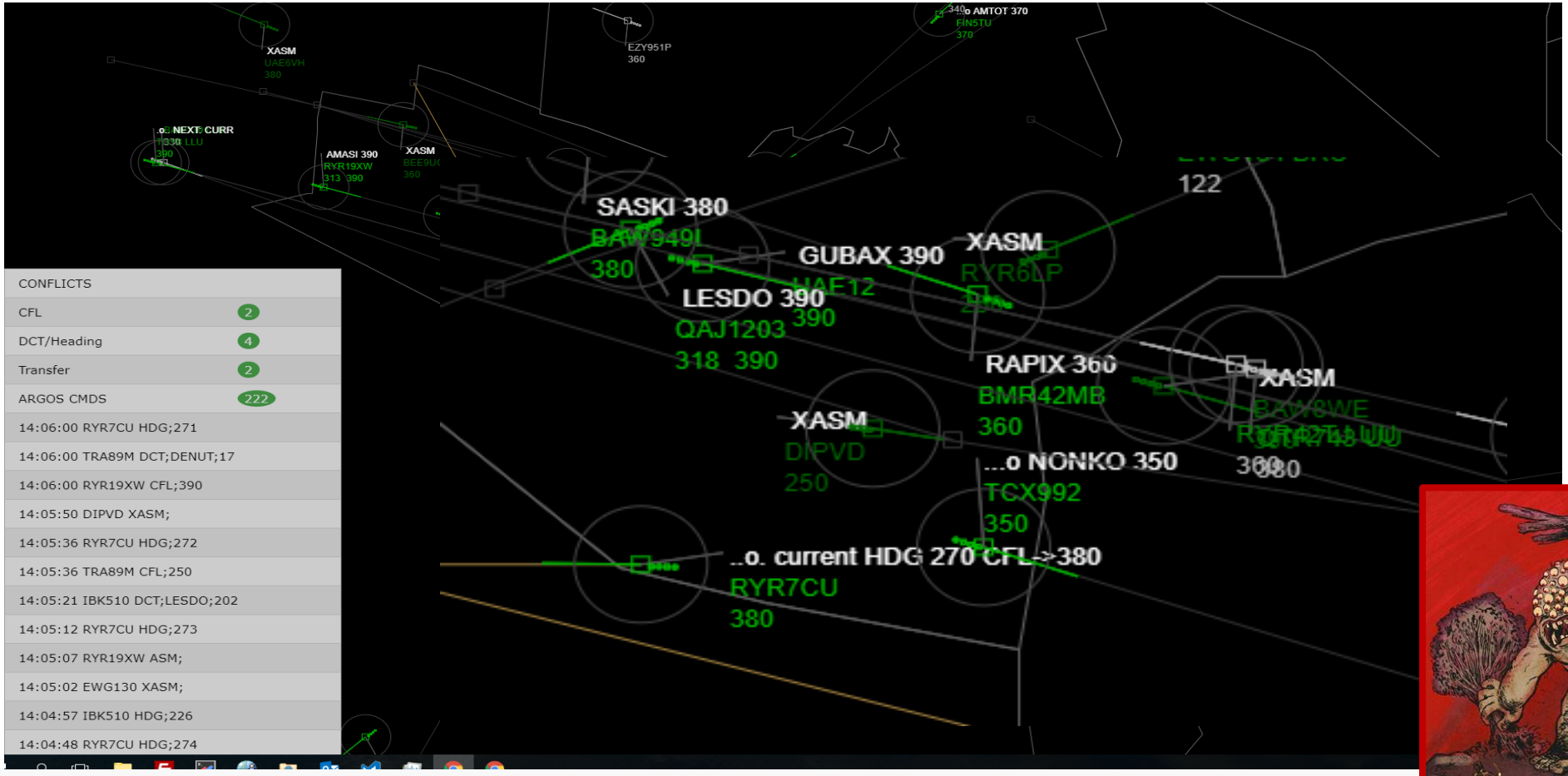
Trajectory Prediction Improvement

Neural network based traffic prediction in iFMP





ARGOS Demo Time



Thank you! Questions?

"IF I HAD ASKED PEOPLE WHAT THEY WANTED, THEY WOULD HAVE SAID FASTER HORSES"
HENRY FORD

"PEOPLE DON'T KNOW WHAT THEY WANT UNTIL YOU SHOW THEM."
STEVE JOBS

peter.hendrickx@eurocontrol.int adam.tisza@eurocontrol.int