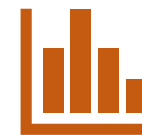


AI Implementation and Experience in Air Traffic Management Automation System

Yi Wen | June 2023, Bangkok



REVIEW



EFFORTS



OUTLOOK



DISCUSSION



REVIEW

AI Roadmap – the Perspective of EASA and CAAC

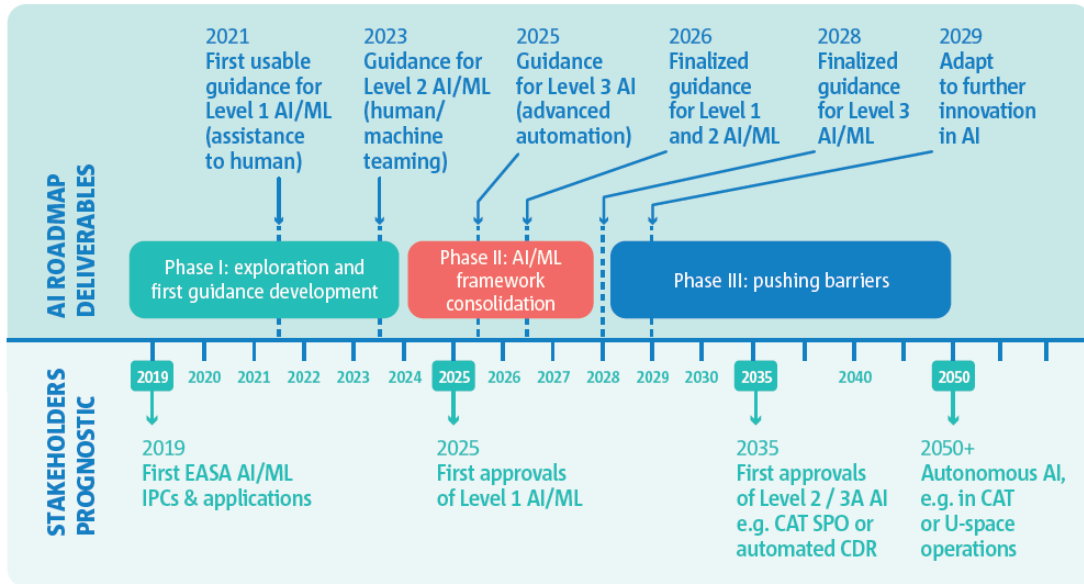
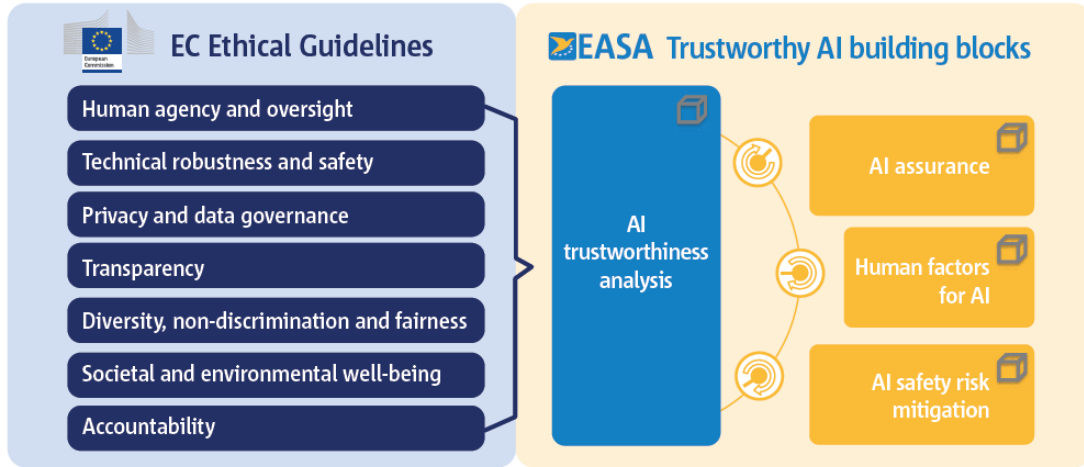
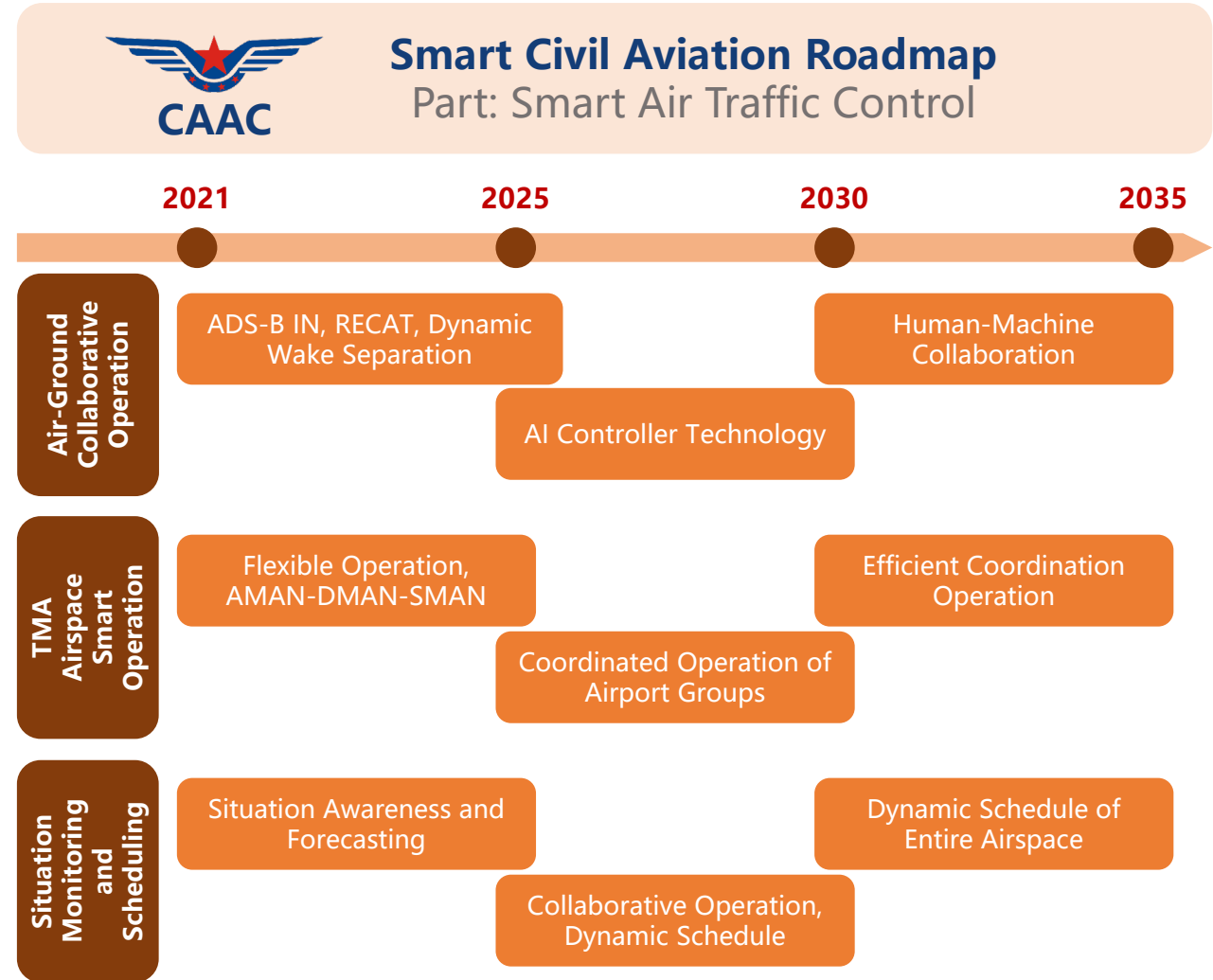


Image: Artificial Intelligence Roadmap 2.0 - Human-centric approach to AI in aviation

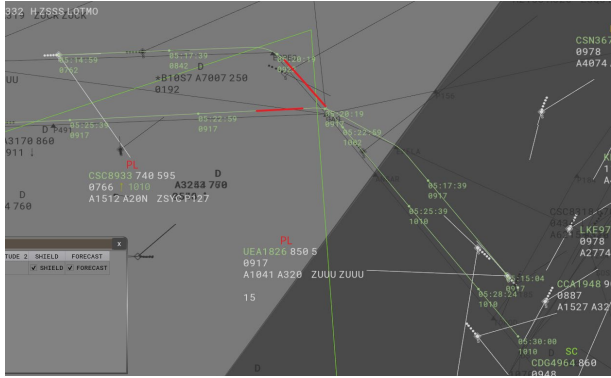


Scenarios	Benefits	Cases
Traffic Forecast Modeling	Improving trajectories prediction, to reduce uncertainty and increase capacity.	ECTL – EUROCONTROL PREDICT System
Resource Management Optimization	Deploying optimal sector configuration, to optimize the capacity with available resources and support the demand capacity balancing in ATC.	Thales – Airspace Complexity Prediction DSNA – Sector optimization with AI ECTL / Thales – Demand and Capacity Balancing
Workload / Automation	Reducing workloads, improving security.	CDATC – Controller training system, sound events detection
Airport Performance	Increasing runway throughput, reducing airport delays.	Heathrow Airport – Runway occupancy detection with image recognition ECTL – Runway performance prediction EANS – Visual tracking in digital towers
Passenger Experience	Improving transfer experience, speeding up safe boarding.	Heathrow Airport – Smart passenger transfer
Infrastructure of Surveillance	Precise GNSS, improving efficiency with remote / digital tower.	ECTL – GNSS-based applications CDATC – Panoramic image synthesis
Airborne Equipment	Improving verification capabilities. Mitigating risk with security tools. Enhancing safety via computer vision-based taxing, takeoff and landing.	Thales – FMS Verification SESAR / Honeywell – Airborne Computer Vision in Low Visibility Airbus – Automated taxing, takeoff and landing
Airline Performance	Optimizing fuel usage. Proposing more reasonable routes.	Honeywell – Cost management and fuel optimization system ECTL – Route network performance

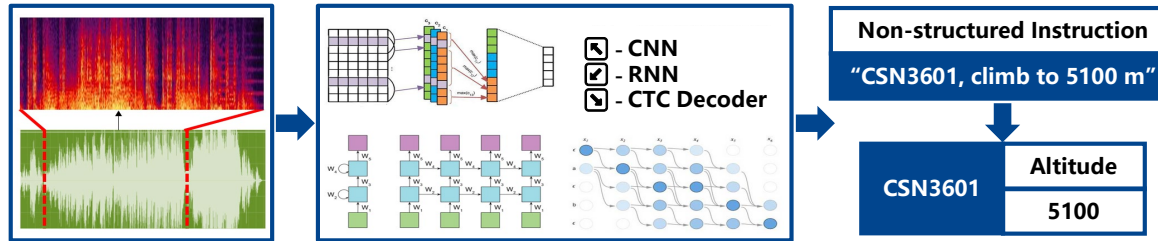
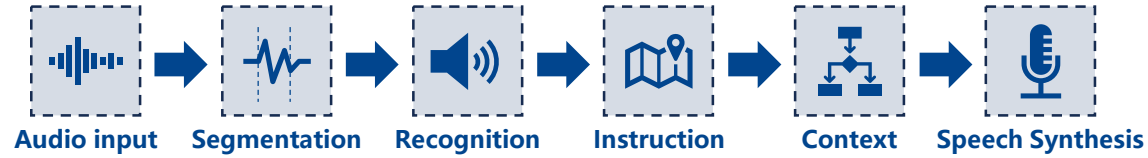
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Speech Synthesis Human-machine Communication

Potential Risk Detection



Workload Evaluation

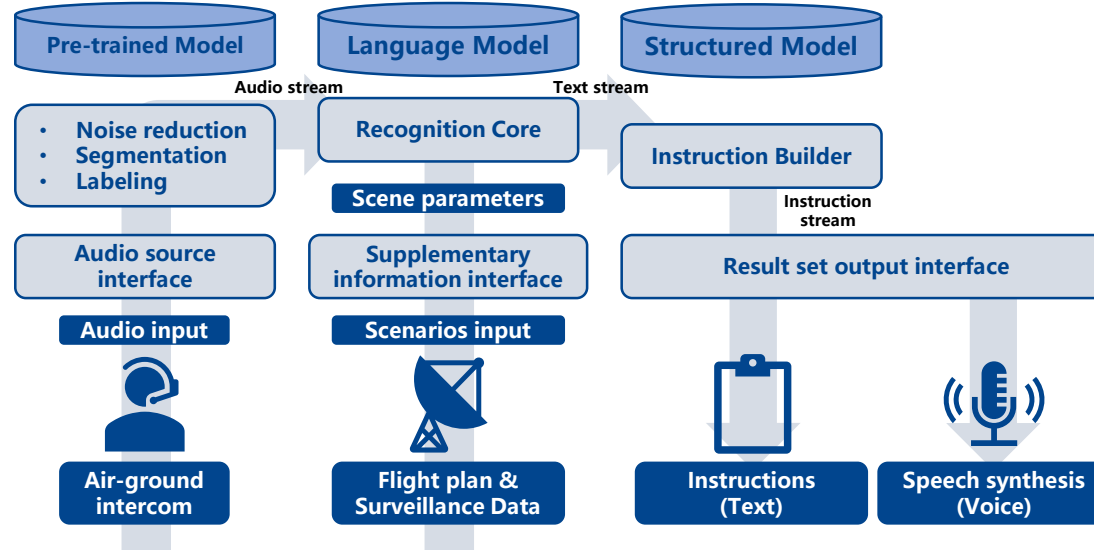


Instructions Recognition

Consistency Check

Response Check

CFL Check



ATCO Training System



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Panoramic image synthesis Identification and Tracking

The Eyes of System



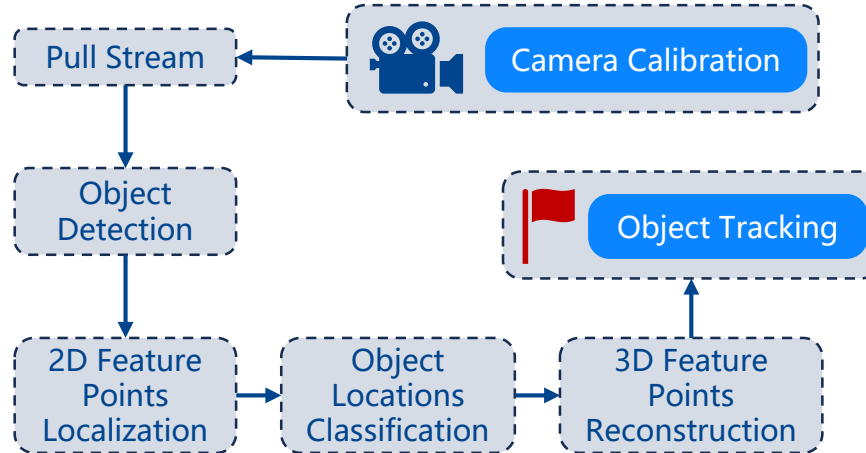
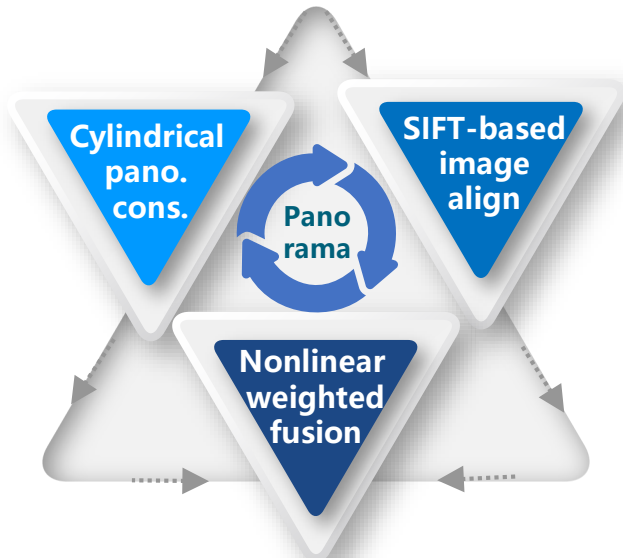
Image Stitching



Video Enhancement



Parallel multi-scale Retinex video enhancement



Pixel Coordinates → Space Coordinates

	1	2		1	2	3
1	1066	672	1	-2.4417e+06	5.0293e+06	3.0597e+06
2	1710	654	2	-2.4417e+06	5.0293e+06	3.0597e+06
3	1506	540	3	-2.4418e+06	5.0294e+06	3.0596e+06
4	1284	580	4	-2.4417e+06	5.0294e+06	3.0596e+06
5	1066	550	5	-2.4417e+06	5.0293e+06	3.0597e+06
6	998	792	6	-2.4417e+06	5.0293e+06	3.0597e+06
7	2192	554	7	-2.4417e+06	5.0294e+06	3.0597e+06
8	770	574	8	-2.4417e+06	5.0293e+06	3.0597e+06
9	768	538	9	-2.4418e+06	5.0294e+06	3.0596e+06
10	420	684	10	-2.4417e+06	5.0293e+06	3.0597e+06
11	2078	532	11	-2.4417e+06	5.0295e+06	3.0595e+06
12	258	556	12	-2.4417e+06	5.0293e+06	3.0597e+06

$$m = K \cdot D \cdot [-R' \quad -R'T] \cdot X$$

$$K = \begin{bmatrix} f_x & \beta & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}$$

$$R = \begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix}$$

$$T = \begin{bmatrix} T_1 \\ T_2 \\ T_3 \end{bmatrix}$$

$$D = [k_1 \quad k_2 \quad p_1 \quad p_2 \quad k_3]$$

EFFORTS

Panoramic image synthesis Identification and Tracking

Identification



Tracking



KLT feature tracker and double-threshold detection

Fusion of Video & Surveillance Data

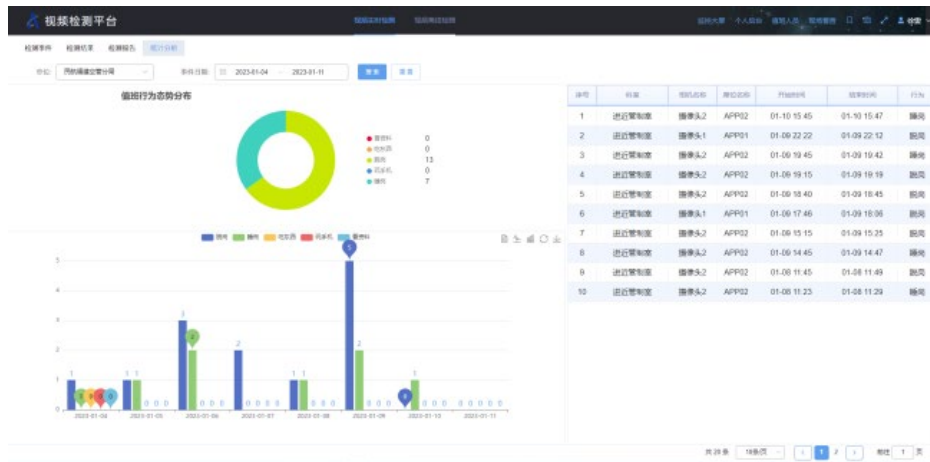


Identify: where the target is, what the target is, and how the target moves

EFFORTS

Human Affairs Profile and Behavior Recognition

Profile-based Smart Scheduling



ATCO Profiles, Work Scheduling

Usage history data as input



Machine Learning

Improve the degree of matching
Human fatigue evaluation

Off-Duty? Eating?
Sleeping? Fatigue?

Real-time
Video Input



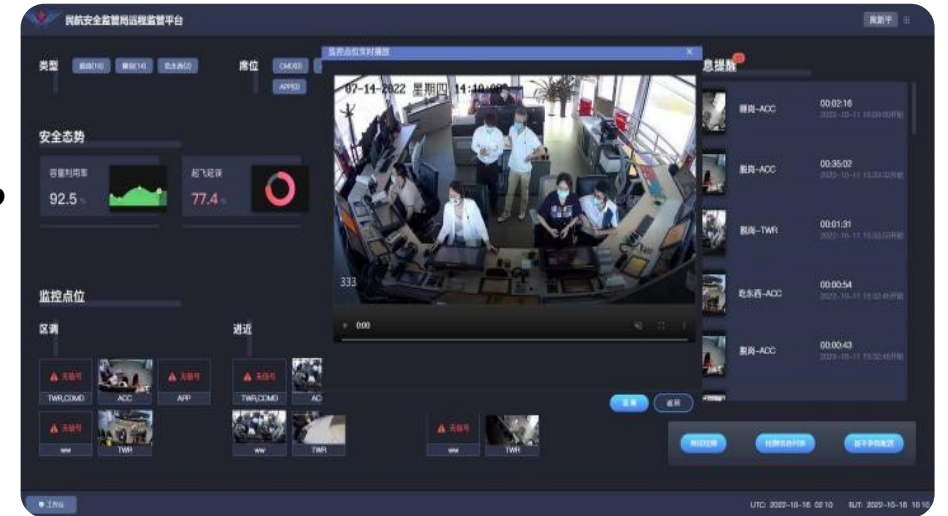
Behavior
Recognition



Illegal Behavior
Warning

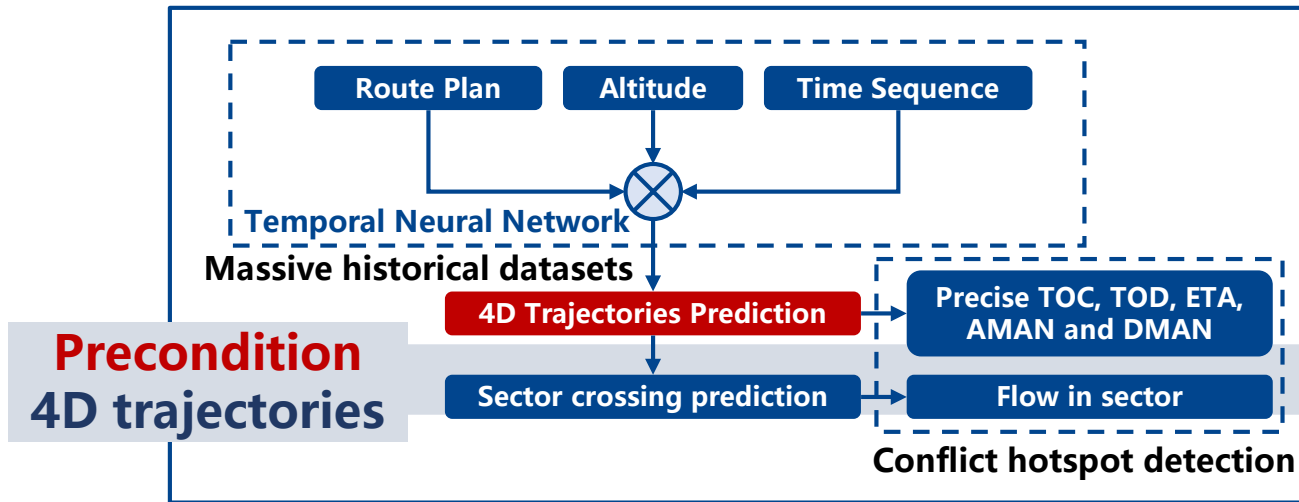


Data Analysis
and Recording



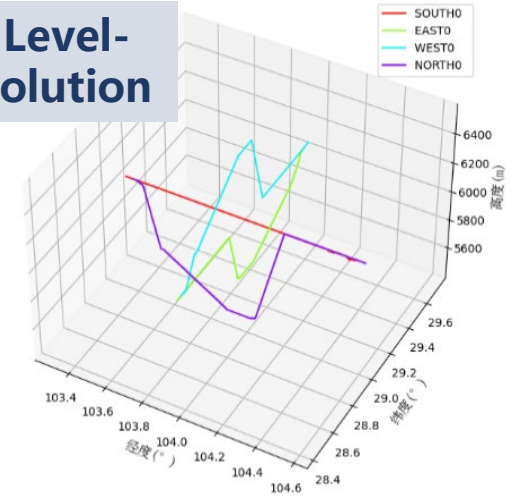
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Trajectories Prediction Conflict Detection & Resolution

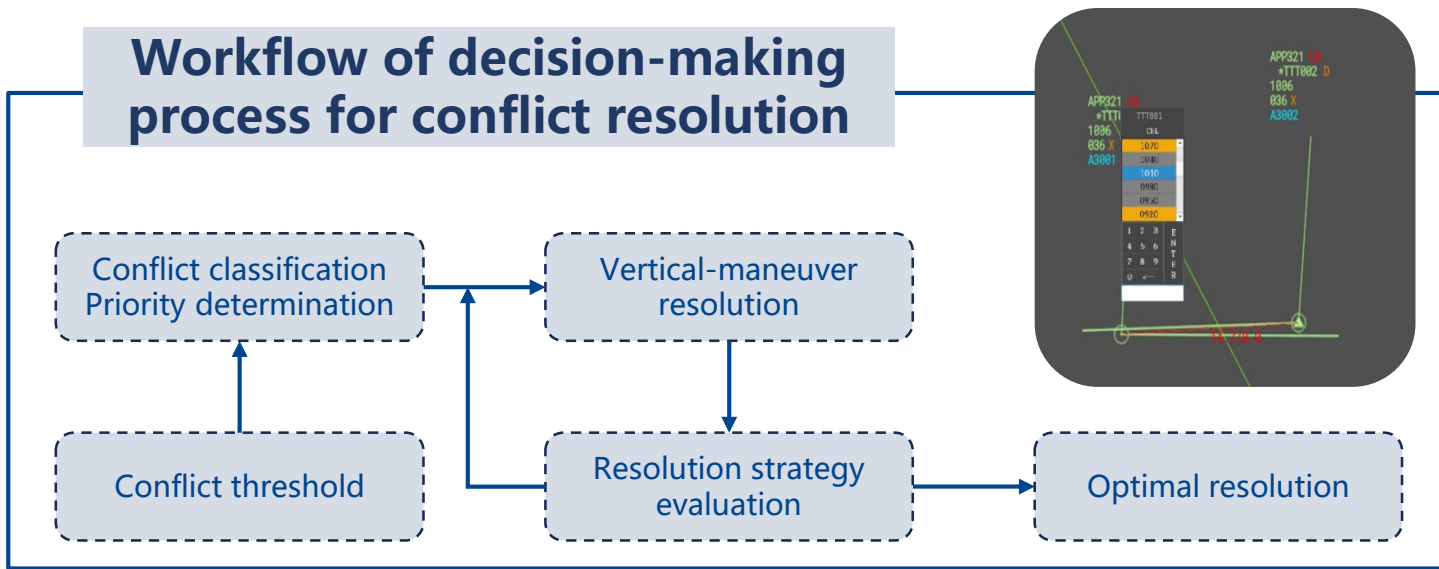


Decision-making for Conflict Resolution

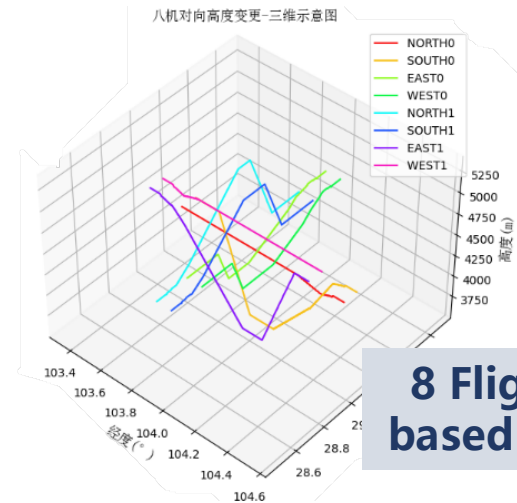
4 Flights Level-based Resolution



Workflow of decision-making process for conflict resolution



八机对向高度变更-三维示意图

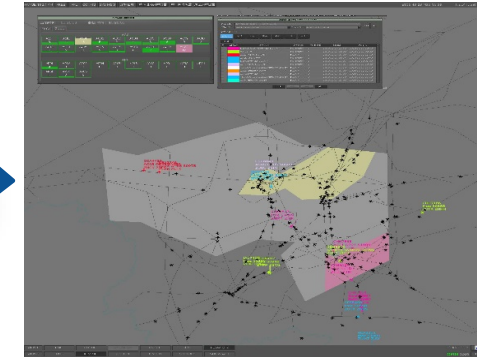
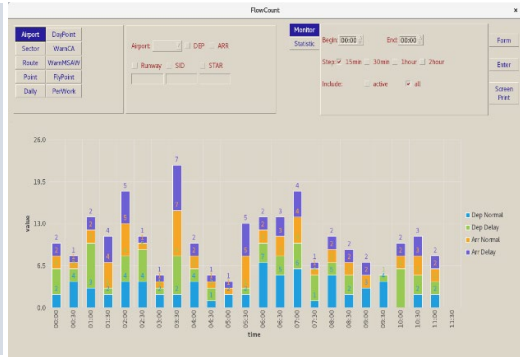


8 Flights Level-based Resolution

EFFORTS

Flow Management (Pre-)Tactical Capacity Manager

Traffic flow forecasting based on machine learning

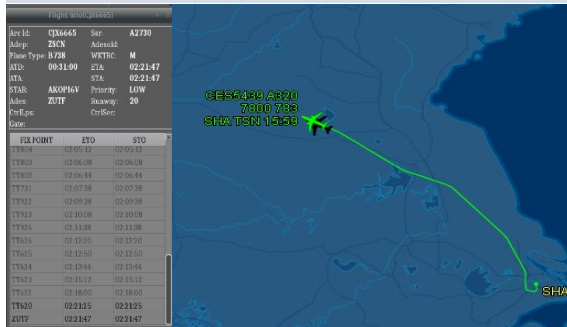


Flow control measures and recommendations

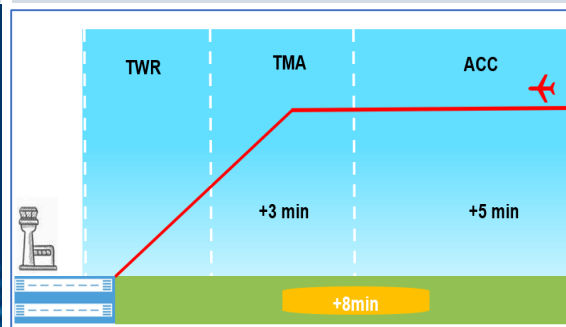
Pre-tactical

Tactical

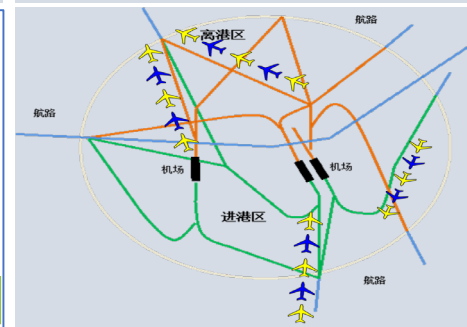
Precise trajectories prediction



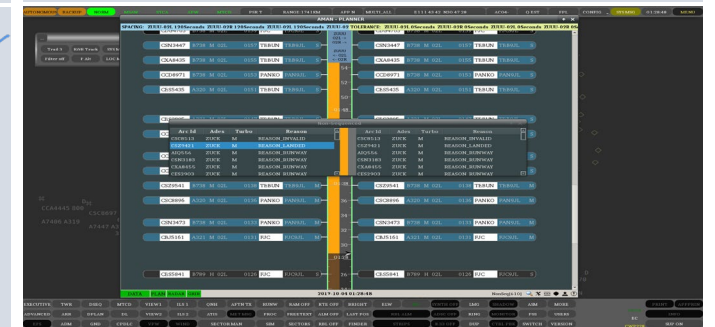
X-MAN extended to ACC



Collaborative sequencing



Sector-scaled ATC delay policy



From ...



GPT-4

Large Language Model (LLM), with ...

- Huge training corpus
- Billion level parameters
- Massive Computing power

#General

#AI

Civil Aviation Skills example

Message (AFTN / SITA / ACARS / TAF / NOTAM) parsing and generating



Explain following TAF: KJFK 210316Z 2106/2206 07004MPS 3000 RA BR BKN002 OVC033 TX16/2106Z TN13/2121Z BECMG 2110/2111 12004MPS TEMPO 2112/2118 0800 -SHRA FG BKN001 OVC033 TEMPO 2118/2124 1500 TSRA BR BKN002 FEW030CB OVC033



The TAF you provided is a Terminal Aerodrome Forecast for John F. Kennedy International Airport (KJFK) in New York City. Here's what it means:

- KJFK: This is the ICAO code for John F. Kennedy International Airport.
- 210316Z: This is the date and time of the forecast, in coordinated universal time (UTC). In this case, it's the 21st day of the month at 0316 UTC.
- 2106/2206: This is the period of the forecast, from 0600 UTC on the 21st to 0600 UTC on the 22nd.
- 07004MPS: This is the wind direction and speed, in degrees and meters per second. In this case, the wind is coming from 070 degrees at 4 meters per second.
- 3000: This is the visibility, in meters. In this case, the visibility is 3000 meters.
- RA: This is the weather condition, in this case it means rain.
- BR: This is another weather condition, meaning mist.
-

In summary, this TAF forecasts rain, mist, and reduced visibility at JFK Airport, with temporary periods of light rain showers, fog, and thunderstorms. The wind direction will change, and there will be broken and overcast cloud cover at various altitudes. The maximum and minimum temperatures are also provided.

OUTLOOK

Breakthroughs Brought by GPT-4

To ...

CA-GPT



Civil Aviation LLM, with ...

- Air-ground communication corpus
- Aeronautical Information Publication
- Image recognition and analysis capabilities

#Narrow, but deeper

#AI

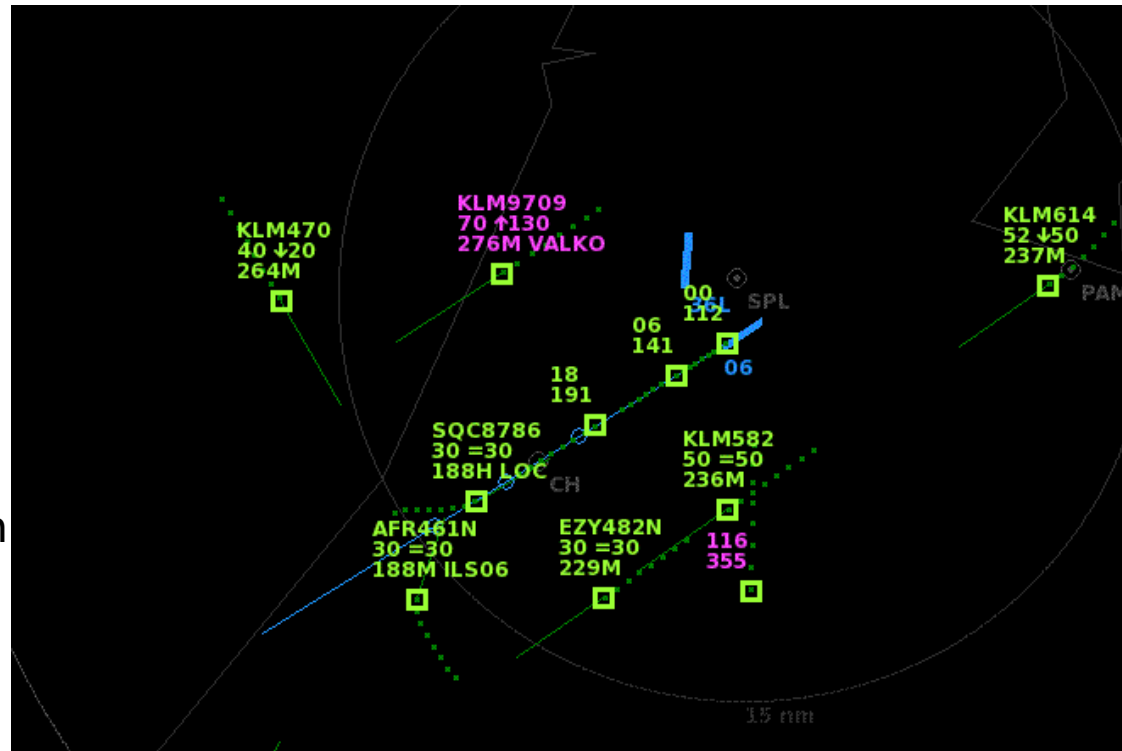
More skills, more complicated

Ground service: Customer Service, Self-check, Luggage...

OCC: Safety management, Maintenance records, Scheduling, ...

ATC: Flights sequencing, control suggestions, ...

ATCOs training: Scenarios generation, role simulation, ...



Simulated airspace around Amsterdam Schiphol Airport

ATC How long does it take for KLM367 to land?

ATC Suggest possible detour route for VLG25H.

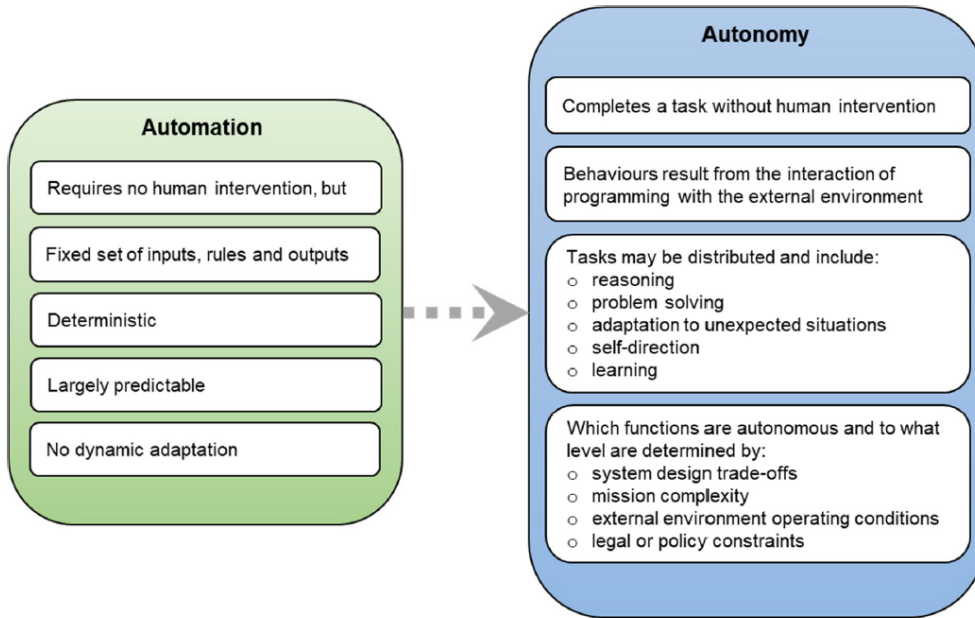
ATC Predict all possible conflicts, and give resolutions.

ATC Generate arrival sequence for all current flights.



OUTLOOK

From Automation to Autonomy



Accurate 4D Trajectories

Flight routes planning

Milestone: CCO & CDO

Ultimate Goal: TBO



Aircraft Flight Prediction

Situational Awareness

Resource Management

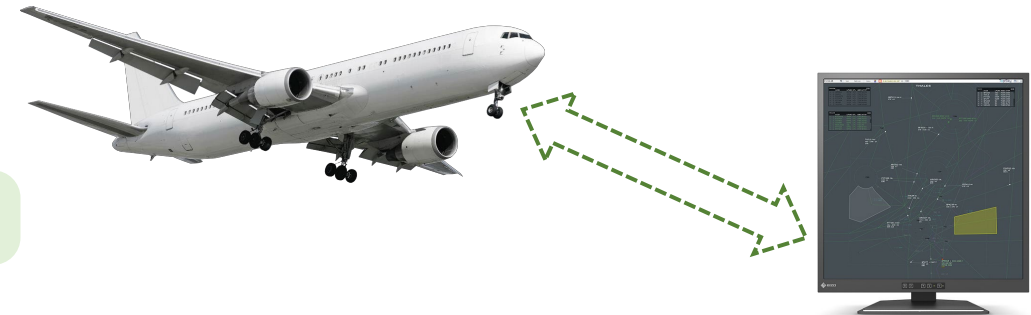
Capacity Balance

Image: Kistan T, Gardi A, Sabatini R. Machine learning and cognitive ergonomics in air traffic management: Recent developments and considerations for certification[J]. Aerospace, 2018, 5(4): 103.



Robo-controller

Future Facilities



Automatic interaction based on ground-air data link

OUTLOOK

Cognitive Human Machine Interface (C-HMI)



Touch and Gesture



Eye Trackers



Electroencephalograms (brain-computer interface)

- Expand ATCOs' perception
- Anomaly detection
- Prompt for missing key info

Intuitive HMI techniques with new modalities

- **An Attempt** Auto highlight or fade-out flights' label with high or low conflict probability

<https://www.sesarju.eu/sesar-solutions/attention-guidance>

GUI behavior

- Cursor movement prediction
- Operation habit learning
- Highlighted map elements
- Automatically popped-up windows



On-duty status

- Human fatigue warning
- Intelligent on-duty prompt
- Facial expression and body language assessment

ATCO behavior analysis & prediction

DISCUSSION Ideal VS Reality



Credibility

- Explainable AI?
- The decision-making should be more reasonable and credible.



Security

- Network Security Protection
- Be wary of data pollution



Personnel capacity

- Human training cost
- To reduce dependence on machine decision-making
- Person should not be a vassal of AI

THANKS

