

COE TTHP Third Annual Technical Meeting

HF003

Characterization of Visual Scanning and Aircraft Control Strategies for Training

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**Center of Excellence for
Technical Training &
Human Performance**

Summary

HF001 (A17-0162) – Characterization and application of air traffic controllers' visual search patterns and control strategies for effective and efficient training



VALUE

Can save training time and cost by providing experts' strategies through multimedia training materials.

Provide cohesive and hierarchical analysis results using realistic and diverse conflict scenarios.

Can be used by instructors, trainees, and research communities (i.e. human factors, aviation, aerospace) to develop improved training methods or human-centered systems.

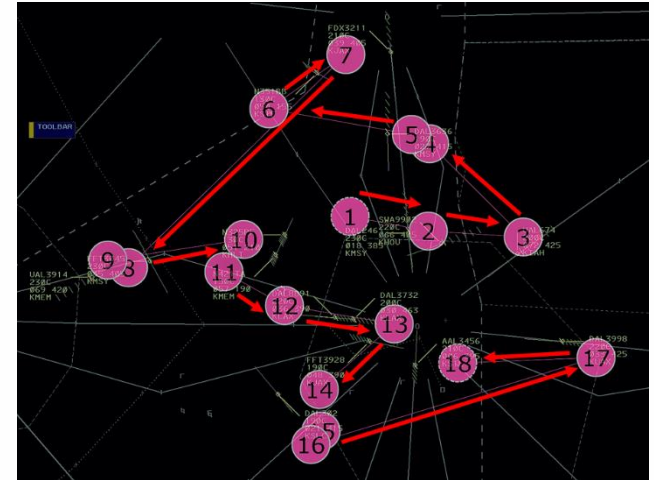
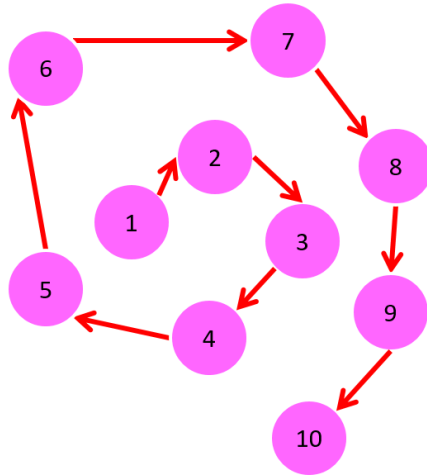


END
STATE

- 1 technical report (161 pages).
- 1 multimedia report on general strategies.
- 12 multimedia reports on specific strategies applied to each scenario type.
- 1 report containing transcribed data.
- 1 journal paper published.
- 3 conference papers published.

Key Takeaways

- Dominant visual search and aircraft control strategies were discovered.
- Other diverse strategies were discovered based on factors such as conflict types, sector characteristics, and customer service priorities.
- Developed visualized examples that are easy to understand.



A spiral pattern, one among five discovered patterns (i.e. spiral, circular, linear, quadrant, mixed), is provided in the example. Twelve different types of conflict scenarios (i.e. converging, head-on, tailgating, streamlined, etc.) were tested out with eleven experts.

Research Results: Findings, Recommendations, Benefits

Findings	Recommendations	Benefits
<ol style="list-style-type: none">1. Discovered dominant visual search and control strategies.2. Discovered other diverse strategies that can play an important role under specific conditions.	<ol style="list-style-type: none">1. Implement general and specific results to support training.2. Utilize video files for training: Show time-ordered visual scanning patterns of experts.3. Utilize developed scenarios for training: Have the candidates or novices compare their visual scanning patterns and control strategies with those of the experts.	<ol style="list-style-type: none">1. Save time and cost for training by providing effective strategies.2. Increase interest and motivation in learning such strategies.3. Possibly reduce human errors through learning other diverse strategies used under specific conditions.

Examples

- Contents:

Examples of characterize visual search patterns:

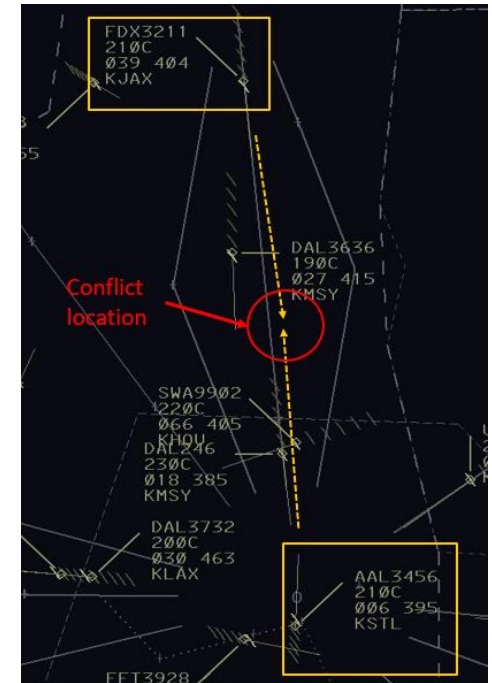
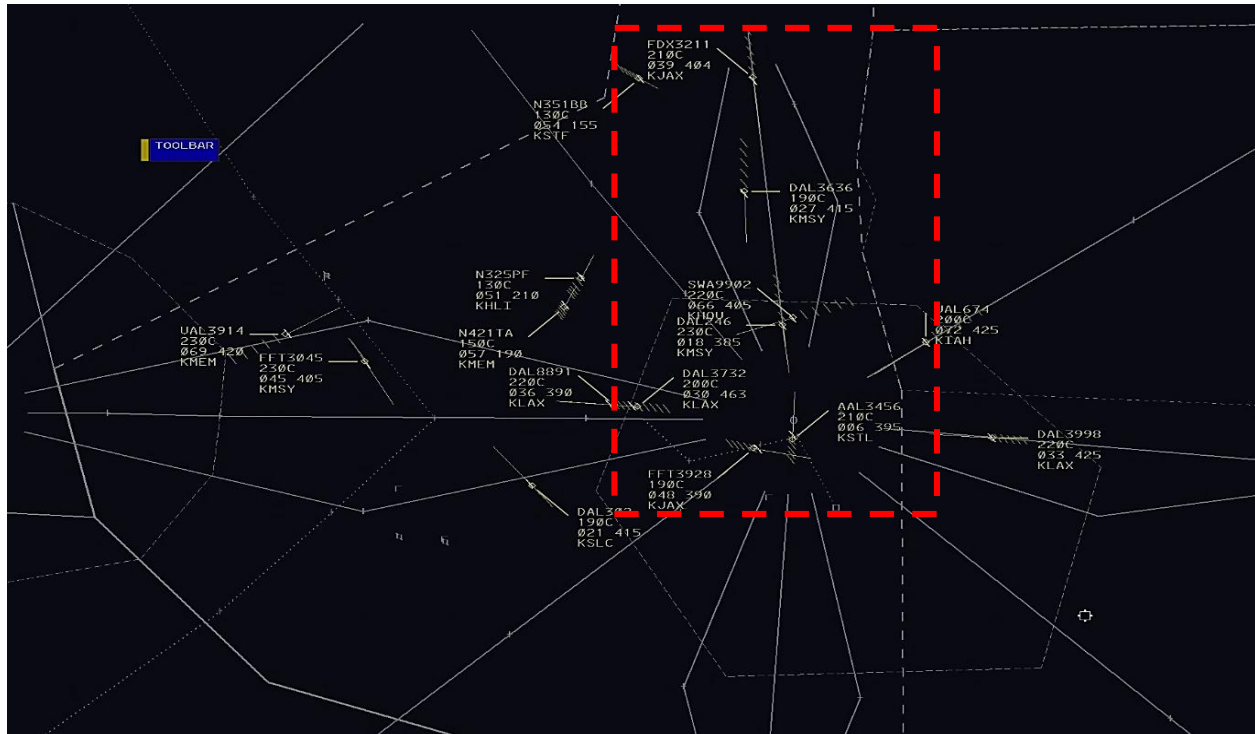
Screen captures and embedded videos

Examples of classified strategies:

Tables and quotes

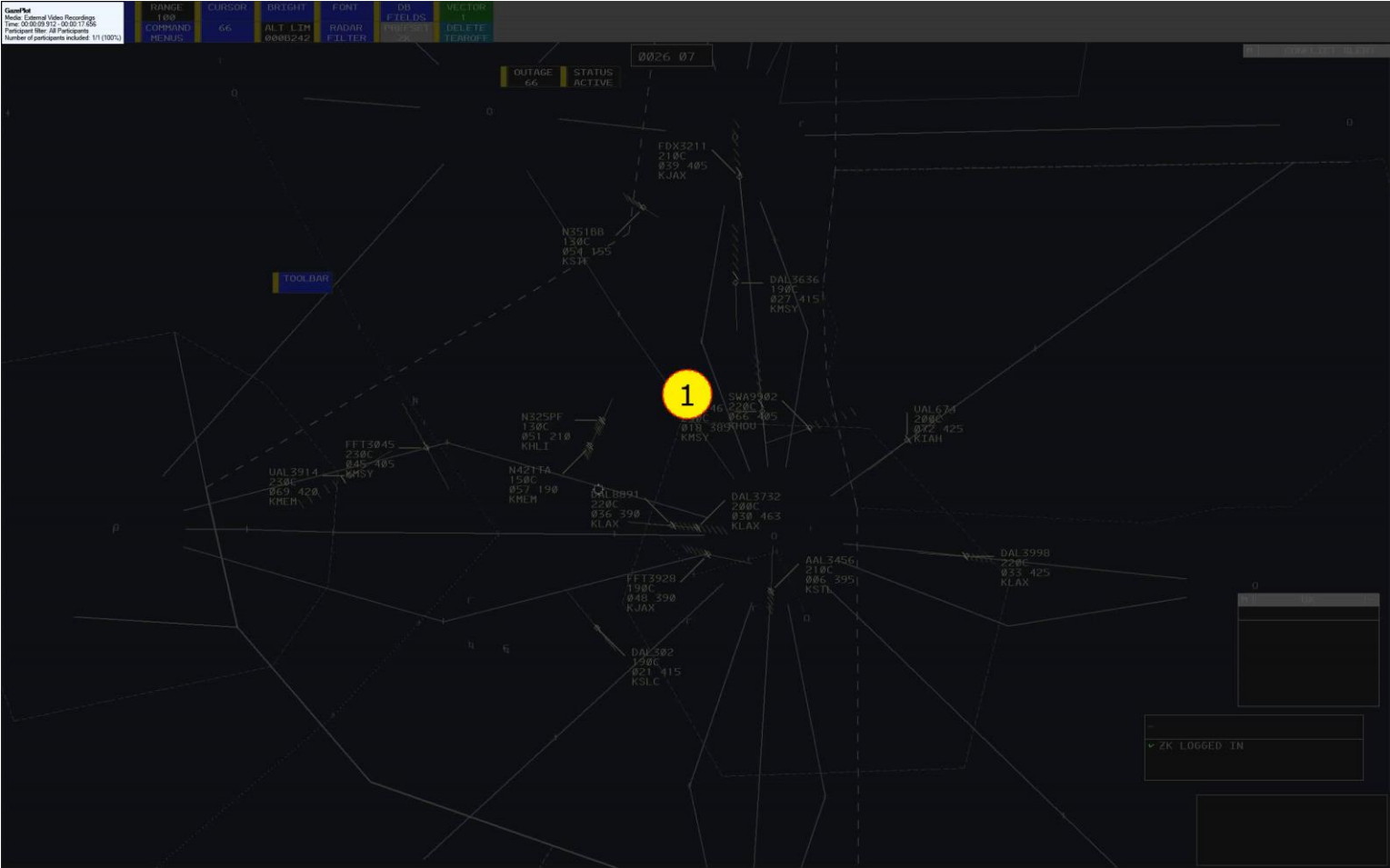
Scenario example I

- Head-on conflict (scenario 5):



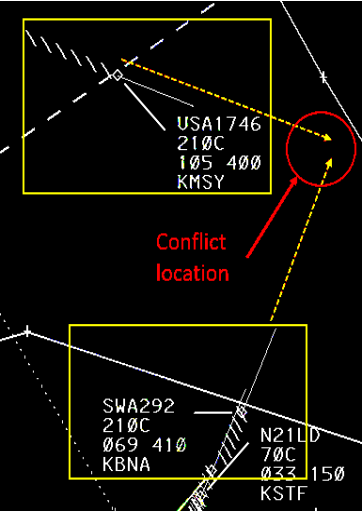
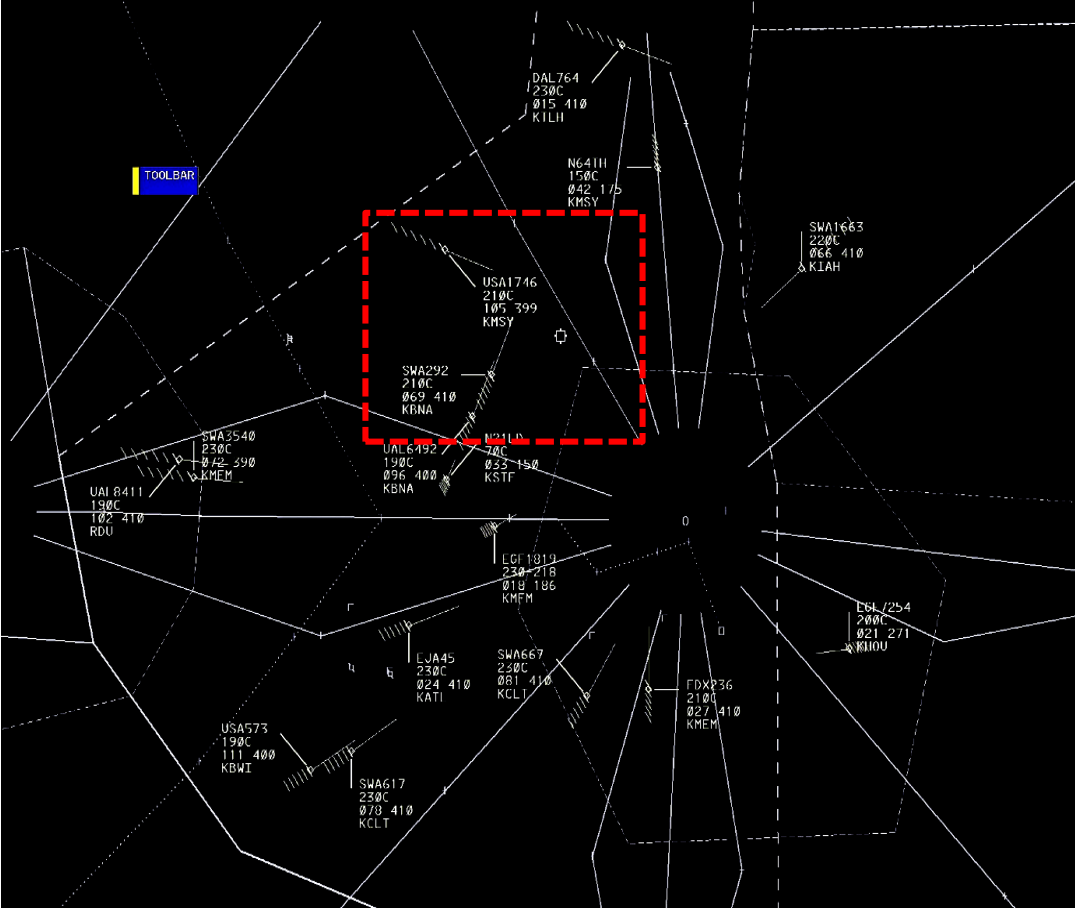
Example of time-ordered visual search pattern I (video)

- Example of outward spiral scan path (embedded video):



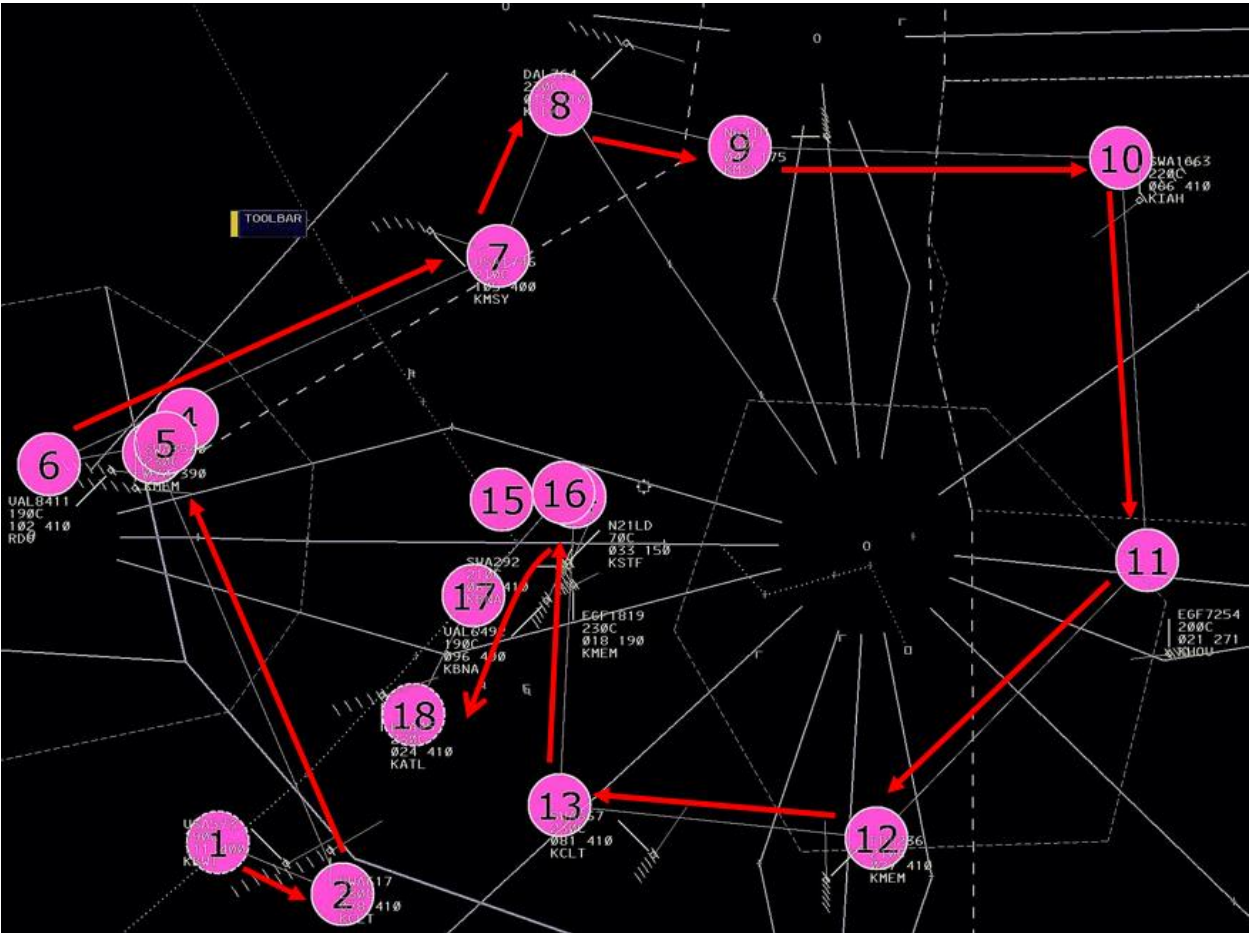
Scenario example II

- Converging or angled conflict (scenario 3):



Example of time-ordered visual search pattern II

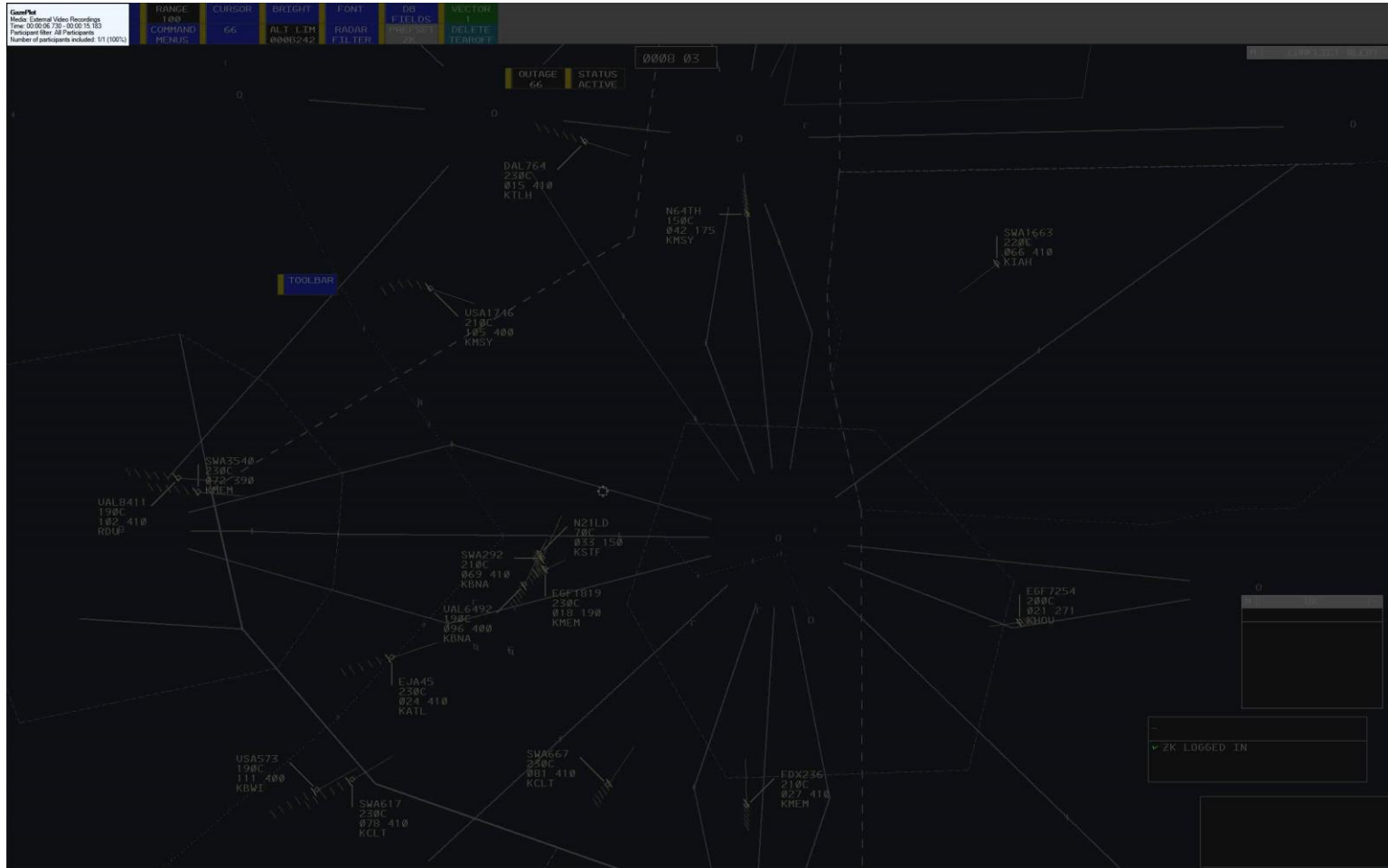
- Example of an inward spiral scan path (screen capture):



Processed pattern using raw eye tracking data

Example of time-ordered visual search pattern II (video)

- Example of inward spiral scan path (embedded video):



Example of classified strategies I

Table G1-1(a). General visual search strategies.

Geometrical pattern	Freq.	Starting location	Freq.	Participant
Spiral	4	High density-based	3	P2, P10, P11
		Center of sector	1	P9
Circular	2	High density-based	1	P1
		Preference based on training and experience	1	P3
Linear (e.g. zigzag)	1	Low density-based	1	P5
Quadrants	1	Areas of conflict	1	P4
Mixed (circular + linear)	1	High density-based	1	P6
Random	2	Incoming sector traffic	1	P8
		High density-based	1	P7

Some reasons for spiral or circular scans:

“Spiral scan provides a continual flow and I don’t need to jumping all over.”

“Spiral scan is the fastest way to get to everybody.”

“If I stay with a sweep, then it is least likely to miss any aircraft.”

Note: In-depth classifications are provided in the report.

Example of classified strategies II

Table G3-1(a). General conflict mitigation strategies.

Preferred order of conflict mitigation strategies			Freq.	Participant
Altitude change	Vector change	Speed change	4	P3, P5, P8, P10
Vector change	Altitude change		4	P4, P6, P7 P9
Altitude change	Vector change		1	P1
Sector Characteristics			2	P2, P11

Preferring altitude change:

“Altitude change may be a quicker method, followed by vectoring.”

Preferring vector change:

“Vector an aircraft with a shorter route and leave it at current altitude if possible. Changing altitudes can be risky since I have to consider current altitude, desired altitude, and interim altitudes in-between. Therefore, temporarily change its route can be the best way to mitigate a conflict.”

Note: In-depth classifications is provided in the report.

Publications

- Kang, Z., Mandal, S., and Dyer, J. (2017). Data visualization approaches in eye tracking to support the learning of air traffic control operations. In *Proceedings of the 2017 National Training Aircraft Symposium (NTAS)*, Aug. 14-16. Daytona Beach, FL.
- Kang, Z. (2017). Real time eye movement analysis framework. In *Proceedings of the 2nd International Conference on Bio-engineering for Smart Technologies (2017 BioSmart)*, Aug. 30-Sep. 1, Paris, France. **(Received Best Presentation Award.)**
- Fraga, R. P., Kang, Z. and Mandal, S. (2018). Characterization of air traffic controllers' visual search patterns and control strategies. In *Proceedings of the 2018 ICSTEM*, Jun. 18-19, Seoul, South Korea.
- Mandal, S. and Kang, Z. (2018). Using eye movement data visualization to enhance training of air traffic controllers: A directed network approach. *Journal of Eye Movement Research*, 11(4), 1-20.

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