Evaluation of Conflict Detection Based on Probability

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Conflict Probability

- Conflict detection based on probability, not nominal minimal separation
  - “Richard Irvine (EUROCONTROL): Target Miss Distance to Achieve a Required Probability of Conflict”

- Probability computed based on:
  - Along-track error
  - Angle of approach
  - Speed of aircraft

![Graph showing probability of conflict and minimum displacement distribution](image)
Conflict Probability

- Angle of approach 90 degrees
- Same speed
- Along-track error 0.1 and 0.4 nm / min
- Conflict defined as separation <7 nm
AgentFly Simulation

- Large-scale fast-time simulation
- Modeling environment, aircraft, and air traffic controllers behavior
- Bottom-up approach

- Analysis, Evaluation, Integration, Validation
  - Large-case studies focused on behavior - what-if analysis
  - Development of new tools / features for current / future systems
  - Providing better environment / interaction for HITL experiments
  - Allows to study future concepts - e.g. coordination between ATCo and UAS operators

- Used for FAA NextGen and SESAR projects
Modular architecture used for various actors – air traffic controllers (en-route, TMA, executive, planning),

Behavior model

- Based on simplified Multiple Resource Theory (MRT)
  - pools of resources
  - actions processed sequentially if require the same resources
  - performance is decreasing when model is overloaded and there is no available resource

- VCAP model using four resources
  - Visual, Auditory – models external stimuli
  - Cognitive – information processing
  - Psychomotor – physical actions

- User defined modules
  - Tasks – handoff, conflict detection and resolution, clearance application, etc.
  - Actions – thinking, giving radio instructions, listening, etc.
### Cognitive Human Behavior Model

#### SECTOR RADIO

<table>
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<tr>
<th>Time</th>
<th>Callsign</th>
<th>Message Content</th>
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<td>NAX84PG, Roger (Contact)</td>
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<td>VKG1142, contact LZBB on &lt;LZBB&gt;</td>
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<td>[4116]</td>
<td>BOX530, climb FL 350</td>
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#### KEYBOARD INPUT

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Czech Airspace

- Smaller area, medium to high complexity
- Approx. 3000 flights per day
- High number of vertical movements
- Up to 12 en-route sectors (3 horizontal, 4 vertical divisions)
Study within SESAR PJ 10.2a with Czech ANSP and EUROCONTROL

Current traffic, sectorization using 7 sectors

Measuring impact on both Executive (R-side) and Planning (D-side) ATC

Trajectory prediction (TP) error defined for cruise and doubled for climb/descend
  - Measured for 0.05, 0.1, 0.15, 0.2, and 0.3 nm / min
  - Conflict decision threshold 10% - 90%

Measuring
  - Number of conflict resolutions
  - Taskload
  - Cognitive workload
Detected Conflicts

Number of detected conflicts with fixed TP error 0.05/0.1 NM/min

Number of detected conflicts with fixed TP error 0.3/0.6 NM/min
Number of detected conflicts within 15min+ lookahead

Threshold [%]

- 0.05/0.1
- 0.15/0.3
- 0.1/0.2
- 0.2/0.4
- 0.3/0.6

Detected Conflicts
Conclusions

- Improving TP error significantly reduces number of detected conflicts, increases precision of detection and allows greater look-ahead.

- Conflict detection decision threshold needs to be defined carefully to minimize false negatives and false positives.

- Earlier conflict resolution improves trajectories and can save fuel.
Validation of ATCo Behavior Model

- Cooperation with FAA, TASC, Drexel University
- Comparison of Human-in-the-loop (HITL) experiment and AgentFly simulation using similar input data
- Human performance metrics:
  - Workload
  - Simplified Dynamic Density (SDD)
  - Aircrafts under control, handoffs
  - Flight Level (FL) occupancy
  - Aircraft mix, climbing, descending
- System performance metrics:
  - Average sector flight time
  - Minimum separation distance
Executive Controller Workload

EC - Workload

Average Workload

Decision threshold [%]

0,05/0,1 EC
0,1/0,2 EC
0,15/0,3 EC
0,2/0,4 EC
0,3/0,6 EC