RA Downlink Experiment

Methodological Issues

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Issues to be Validated

RA Downlink improves "local" Situation Awareness?

- No contradicting clearances;
- Traffic information;
- Post-conflict traffic planning.

RA Downlink does not deteriorate "global" Situation Awareness?

- Information overload;
- Distraction;
- Confusion;
- False alarms;
- Unclear pilot-controller responsibility.
"Swiss Cheese" Safety Metaphor

Safety Hazards

Collision Avoidance

Potential for conflicting clearance

Responsibility shifting

Mid-Air Collision

DEFENSES

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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“Swiss Cheese” Safety Metaphor

- Safety Hazards
- Conflict Avoidance
- Collision Avoidance

DEFENSES

- Training
- Sectorization
- Procedures
- STCA
- TCAS

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RADE Validation Approach

ACAS Database

ACAS Themes
- ATC error
- Pilot error
- Combination of 1 and 2
- High VS level-off
- False RA

Generic ATC environment

RADE-1 'backward' Validation
Replay of reconstructed real RA situations
Non-interactive Monitoring Scenarios

RADE-2 'forward' Validation
Simulation of RA-facilitating situations
Interactive Control Scenarios

ACAS Themes
- ATC error
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Issues to be validated
Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings
RADE-2 Aims & Procedure

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RADE-1* Methodology

- **Participants**
  - 30 area controllers mixed in operational experience

- **Set Up**
  - Observation of 15 traffic scenarios
  - Based on real RAs
  - Supplemented with R/T and additional background traffic

* Full report available at: http://www.eurocontrol.int/ra-downlink/rade-1.html
RADE-1 – Aims

- Gather controller feedback about operational usefulness of RA downlink, through questionnaires and interviews.
- Explore interface options
- Assess and measure controller reaction to RA display
HMI Solutions

• Options investigated
  ▪ Visual Alert but no indication of RA sense
  ▪ Visual Alert plus indication of exact RA sense
  ▪ Visual/Auditory/Haptic Alert plus indication of exact RA sense

• Derived HMI Design Guiding Principles
  ▪ RA information on the screen should not pose too high demands on the controller’s attentional resources.
  ▪ The controller needs to be immediately aware of whether an RA yields a deviation from the cleared flight path or not.

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Situation Awareness

- Measurements
  - Post-exercise RA memory probe
  - Post-exercise Subjective Questionnaire (SASHA-Q)
  - Eye-Point-Of-Gaze

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Results:

Post-Exercise Memory Probe

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Results (cont’d)

• Subjective Situational Awareness rating collected after each scenario did not reveal any significant positive or negative effects of RA downlink.

• Eye tracking measurements did not point to unusual ‘attention capture’ to RA downlink icon at the expense of other traffic display information.
Results (cont’d)

Controller acceptance:

• The majority of participants saw clear operational benefits in the provision of RA information to the controller.

• If RA downlink is faster and more reliable than a pilot report, it can support controller’s anticipation of aircraft manoeuvres.

• RA downlink may decrease the likelihood of contradictory ATC clearances.
In order to realise benefits of RA downlink, two requirements need to be met:

- RA information on the screen should not pose too high demands on the controller’s attention. In particular, the controller needs to be immediately aware of whether an RA yields a deviation from the cleared flight path or not.

- Operational procedures for the use of RA information need to be defined.
Conclusion

Results of RADE-1 were promising to proceed with the RADE-2 “forward” validation approach.
RADE-2 Aims

- Evaluation of an RA Downlink Operational Concept.
- Obtain empirical data on controller reaction (performance, acceptance) in a realistic interactive simulation scenario setting involving an RA encounter.
Experimental Variables

- RA Downlink
  - Present
  - Absent
- Pilot report
  - Correct and timely
  - Delayed (RA report after the COC).
- Controller Position
  - Executive
  - Planner
- Manipulated in a 2 * 2 * 2 experimental design resulting in a total of 8 simulation runs.
- The participants are not informed in advance which pilot report condition will be used.
- Experimental run order is different for each group.
RA Generation

• The aim is to generate or facilitate RAs in a realistic and non-intrusive way.

This is achieved by:

• Predicting controller’s actions.
• Identifying traffic situations that may allow generation of an RA.
• Adjusting workload.
• Introducing errors.
• Varying aircraft behaviour.
• Sector characteristics.
• Similar call signs.

• Repeated attempts on the same aircraft or using the same method are avoided (as controllers find this annoying).
Successful Run Criteria

• Experimental run is deemed successful if an operationally realistic RA occurs.
• Once the RA occurs the scenario is terminated after 2-3 minutes.
• Immediately after the RA, probing questions are asked to assess controller’s Situational Awareness.
• A run will be declared unsuccessful if:
  ▪ No RA has occurred after 50 min.
  ▪ The RA is deemed unrealistic
  ▪ Realism of simulation has been lost for whatever reason
  ▪ Technical failures
Controller Error

- Incorrect clearance or instruction.
- Undetected incorrect read-back.

Facilitating Methods for the SME:
- Increase workload by requesting a change of flight level or by requesting direct routing as often as realistic.
- Incorrect read-back.
- Read-back from the other airplane (using callsign similarity).
Pilot Error

- Level bust.
- Turn instead of level change or vice versa (e.g. heading 310 instead of level 310).
- Any other non-compliance with ATC instructions/clearances.

Facilitating Methods for the SME:
- Pilot disobedys the clearance.
- Pilot selects a path along a wrong route.
- Slow pilot response
High Vertical Rate Level-off

- RA caused by high vertical speed prior to level-off 1000 feet apart from other aircraft.

Facilitating Methods for the SME:
- Instruct the pilot to manipulate the vertical rate.
Imminent Conflict

When a situation that potentially may result in an RA:

- Pilots may delay response to any calls from the controller.
- Pilots may distract the controller attention by making a call from an aircraft not involved in the potential conflict.
- SME Coordinator will create heavy coordination workload on the planning controller.
RA Generation Guideline

- Controllers are exposed to the situations in which, despite their best efforts, conflict and RAs will occur.
- Controller confidence might be shaken.
  - Controllers must not be placed in the position when they have to justify themselves.
  - We never judge controller performance.
Measurements

Situation Awareness

- Post-exercise RA memory probe
- Post-exercise Subjective Questionnaire (SASHA-Q)
- Situation Awareness online probe
- Post-exercise debriefing
  - replay with/without RA downlink display
  - think-aloud protocol
Other Measurements

- **Workload**
  - NASA-TLX subjective workload rating
  - Late transfers (embedded secondary task workload index)

- **Controller Acceptance**
  - Simulation realism (post-exercise debriefing)
  - Operational Concept (post-experiment debriefing, final debriefing)
  - Replay with/without RA downlink display
  - Think-aloud protocol

- **Simulation recordings**
Objective Measurements

- The number of instances:
  - when a controller issued an instruction to an aircraft with an RA.
  - when a controller gave traffic information to involved aircraft (i.e. aircraft with RA and third-party aircraft), as well as the quality of this traffic information.
  - of follow-up conflicts involving third-party aircraft and RA aircraft after RA manoeuvres.
- Number and severity of conflicts (in terms of spacing) that triggered RA events.
- Controllers’ response times to pilot requests following an RA (unrelated to the RA situation).
- Average latency of RA display on CWP.
**Simulation Realism (preliminary)**

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<th>Group 1</th>
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<th>Group 3</th>
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<td>4.1</td>
<td>4.5</td>
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<tr>
<td>RA event realistic</td>
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<td>Pilot response to RA realistic</td>
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<td>4.4</td>
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Scale: 1 (not at all) to 5 (absolutely)
www.eurocontrol.int/ra-downlink

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